THE REFERENCE SHELF

is published to make available when needed, collections of articles and bibliographies on timely subjects for public discussion. Each number is devoted to a single subject. To make the material available at the time of greatest need, publication is irregular. Each volume contains seven or more separate issues, about 1500 pages in all. Complete volume, $6.00; single numbers as quoted.

The Reference Shelf is listed in the Readers' Guide to Periodical Literature, Education Index, Industrial Arts Index, and Cumulative Book Index.

Future Issues To Be Announced.

Volume XIX. $6

No.

1. International Trade: Cooperative or Competitive? C. A. Peters. $1.25.
2. The Atomic Bomb. J. E Johnsen. $1 25.
3. Free Medical Care. C. A. Peters. $1.25.
4. Representative American Speeches: 1945-1946. A. C. Baird. $1.25.

Volume XVIII. $3.45

No.

3. Representative American Speeches: 1944-1945. A. C. Baird. $1.25.
5. Anatomy of Racial Intolerance. G. B. deHuszar. $1 25.
6. Palestine: Jewish Homeland? J. E. Johnsen. $1.25.
7. American Capitalism vs. Russian Communism. C. A. Peters. $1.25.

Volume XVII. $3.45

No.

1. Basic English. J. E. Johnsen. $1.25.
4. Representative American Speeches: 1943-1944. A. C. Baird. $1.25.
5. Lowering the Voting Age. J. E. Johnsen. $1.25.
7. Postwar Wage Stabilization. J. E. Johnsen. $1.25.

Volume XVI. $6

No.

1. Representative American Speeches: 1941-1942. A. C. Baird. $1.25.
2. Plans for a Postwar World. J. E. Johnsen. $1 25.
3. Independence for India. J. E. Johnsen. $1 25.
4. Wage Stabilization and Inflation. J. E. Johnsen. $1.25.
5. World Peace Plans. J. E. Johnsen. $1.25.
6. Representative American Speeches: 1942-1943. A. C. Baird. $1.25.
7. Reconstituting the League of Nations. J. E. Johnsen. $1.25.

THE REFERENCE SHE[LF]

Volume XV. $5.40

No.
1. Representative American Speeches: 1940-1941. A. C. Baird $1 25.
2. Universal Military Service. R. E Summers and H. B. Summers. $1.25.
3. Federal Regulation of Labor Unions. J. V. Garland. $1.25.
4. Federal Price Control. J. E. Johnsen. $1.25.
6. Wages and Prices. R. E Summers $1 25
7. The Closed Shop. J. E. Johnsen. $1 25.
8. Wartime Censorship of Press and Radio. R E. Summers $1 25
9. Permanent Price Control Policy. J E Johnsen $1 25.
10. A Federal Sales Tax. E R Nichols. $1 25

Volume XIV. $3.60

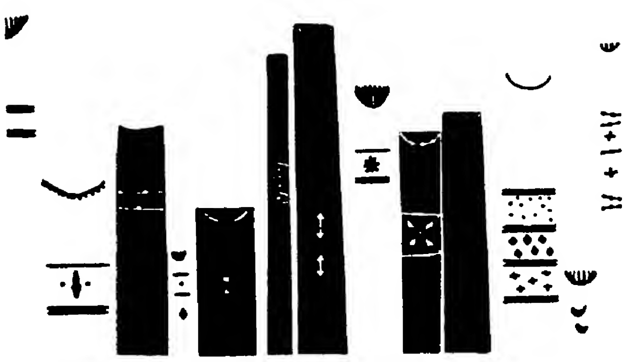
No.
1. Representative American speeches: 1939-1940. A C Baird $1 50
2. Interstate Trade Barriers. J E. Johnsen $1.25
6. Compulsory Military Training. J. E Johnsen $1.25.
8. International Federation of Democracies. J E Johnsen $1.25.
9 Debate Index. Supplement. J. E Johnsen 75c
10. Federal Aid for Education. J E. Johnsen $1 25.

Volume XIII. $3

No.
4. Europe: Versailles to Warsaw. R. S. Kain $1 25.
5. Public Housing in America. M. B. Schnapper $1 25
6. United States Foreign Policy (Supplement) J E Johnsen 75c
9. The National Labor Relations Act. Should It Be Amended? J. E. Johnsen $1.25
10. Trade Unions and the Anti-Trust Laws. J. E. Johnsen. $1.25.

reference collection book

kansas city
public library
kansas city,
missouri



THE REFERENCE SHELF

Vol. 19 No. 2

THE ATOMIC BOMB

Compiled by
JULIA E. JOHNSEN

THE H. W. WILSON COMPANY
NEW YORK 1946

Published October 1946
PRINTED IN THE UNITED STATES OF AMERICA

PREFACE

The atomic bomb which made its first impact upon the world at Alamogordo on July 16th, 1945, and soon after was instrumental in promoting early peace in the Pacific regions, has been a cause of deep apprehension throughout the world. In the year since its emergence from the secrecy which attended its inception it has been extensively discussed and a considerable literature has grown around it. Those who were most closely associated with its production have in many cases become most zealous in pointing out the momentous implications of the release of this new power. Statesmen, world leaders and others of public note have stated or implied that in default of a wise control of this tremendous force the world might face a possible destruction of civilization itself.

In view of such significance of atomic fission it becomes of importance to clarify its principles, and controls. The attempt has been made here to present the factual background and such other helpful material as might contribute to this understanding and to constructive thought and discussion, presenting without bias such divergent views as space may permit. The bibliography is offered as a further contribution to this end The extent of the literature has necessitated various omissions, particularly of earlier date. Such references, as well as other extensive material, appearing in the *Congressional Record*, the *New York Times* and other papers, may be readily located through indexes and otherwise where desired. In general, up-to-date material has been retained as fully as possible. In view of the constant change in status of the attempted controls, domestic and international, and the fact that official statements and documents have grown too large for adequate representation, it has been thought desirable to represent such material sparingly in favor of other important discussions, the more so as they are already widely published and available.

Among the issues posed by the atomic bomb are many fundamental questions relating to our basic ways of life and thought. It has brought up the question of government support of scien-

tific research, of civilian versus military control, of government retention of all rights to fissionable materials and resources, of secrecy versus world sharing of all basic facts of science, of the veto power, sovereignty, and many others. The atomic bomb has provided also a heavy reinforcement to the pressure for a world organization as a basic essential to control of this power.

The responsibility of legislators and statesmen who shape our national and international policies today is great. But the responsibility of each of us is great also, for the understanding of real issues.

The compiler gratefully acknowledges the various courtesies of copyright permissions given, and the furnishing of much helpful material that has facilitated the preparation of this work.

July 31, 1946

JULIA E. JOHNSEN

CONTENTS

HISTORY AND DEVELOPMENT OF THE ATOMIC BOMB

ATOMIC ENERGY AND WORLD ORDER[1]

Classical Atomism

In the fifth century before our era the atomic age was founded in Greece by Leucippus of Abdera and his renowned pupil Democritus. It reached its tragic and sensational climax on August 6, 1945, when the atomic bomb of questionable fame obliterated in a moment the Japanese city of Hiroshima with its doomed inhabitants. The beginning of the theory was publicly unnoticed; its appalling culmination in action has alarmed the world.

During the period of nearly twenty-four centuries elapsing between the two events, the atomic theory of matter has triumphantly encountered stranger vicissitudes of fortune than any other hypothesis of science. It has been brilliantly expounded, strongly attacked, fantastically adorned, stricken to apparent death, resuscitated into vigorous life, dignified with sober mathematical attire, endowed with prophetic power, and made the basis of an immense domain of natural phenomena. It has unleashed the most concentrated and destructive energy known to man, and finally has given its name to a new era of the world.

For inherent in the idea of the atom from the beginning was the indestructible element of truth. To it have therefore slowly but inevitably been traced the elucidation of the structure and behavior of matter, electricity, and magnetism; the origin of light, and of gravitational, electric, and magnetic forces; the genesis of radioactive changes and of the innumerable reactions upon which the operations of nature, of living organisms, and the chemical industries, which are the basis of modern industrial life, depend. From the atom have sprung the broadcasting and

[1] By Frank Allen, Professor Emeritus of Physics, University of Manitoba. *University of Toronto Quarterly*. 15.256-68. April 1946.

universal reception of voice and music which for the first time have brought all nations into living communion with one another.

Two theories of the nature of matter are conceivable, discontinuity of structure and continuity, the former of which was the earlier to be proposed. The atoms of Democritus were imagined to be excedingly small, indivisible particles of permanent size and inviolable shape. Some had smooth rounded surfaces and therefore could move easily about, like those of water and oil. The rough atoms of salt, interspersed among the smooth atoms of water, rasped the bitter salt taste of sea-water upon the tongue. Acids like vinegar tasted sharp because their atoms had prickly points. The atoms of solids had uneven surfaces with branches that intertwined to hold them firmly together. The quiescent metal was in reality a restless mass of such interlocked atoms which gave the external appearance of rest because they were too small to be seen. To the touch a metal appeared hard since the writhing atoms in matted form resisted pressure. Dispersed atoms constituted thin air and swept through the pores of bodies. Atoms in huge streamers or tongues formed smoke and clouds. No origin of motion was suggested, but it was tacitly assumed that all atoms were naturally in tumultuous movement.

Into the Democritean atomic theory were gathered some of the chief ideas of nature held by the ancient philosophers. Since the restless and immutable atoms rushed, collided, wandered, and combined to produce the incessant phenomena of change, there must be space for the execution of their movements. This was provided by a void or vacuum in which their motions were unhindered. As atoms were too small to be seen, so the empty space at their disposal was likewise unobservable. To later philosophers the existence of a void was repugnant, and this opposition was later crystallized in the principle of Aristotle that no void was possible since nature abhors a vacuum, a doctrine that persisted for about nineteen centuries, until the experiments of Toricelli (1640) on the weight of the air and the production of a vacuum banished it from physics.

Democritus was a follower of the Pythagorean school. It is not surprising, therefore, that the peculiar idea of Pythagoras of numbers being mystical constitutents of things, was implicit in

atomism. While differing widely from that early philosophical concept, number in modern theory is intrinsically associated with atoms in the precise form of atomic weights and numbers, which have a profound physical significance in relation to atomic structure.

The doctrine of elements had for the first time been announced by Thales a century and a half before Democritus. The single primary element of matter was declared by him to be water. While the idea of elements persisted, the primary substance chosen varied from one philosopher to another. In the opinion of Anaximenes it was air, and in that of Heraclitus it was fire. In a more generous spirit these three, together with a fourth terrestrial substance, earth, to which Aristotle at a later date added a more refined celestial element or fifth essence, were all admitted to the hierarchy of elements. At times the elements themselves were thrust into the background and certain properties, cold, hot, moist, and dry, occupied their places. The Democritean atoms, though widely diversified in shape, were held to be immutable parts of a single element. By their different sizes, forms, and grouping all visible things were constituted. When this idea was criticized, Democritus retorted that the same letters of the alphabet which made a tragedy could by rearrangement compose a comedy!

About sixty years after Democritus had set forth his view of atomism, Plato in the *Timaeus* expounded an alternative system of geometrical atomism. The existence of only five regular solids so strongly impressed the great philosopher, that he believed them to be connected with other manifestations of nature. The four elements of matter appeared singularly adapted to this purpose; and accordingly the atoms or particles of air were assumed to be octahedra, those of earth cubes, those of fire tetrahedra, and of water icosihedra. The fifth solid, the dodecahedron, having then no corresponding element, was conveniently assigned to the plan of the universe itself.

A third system of atomism was propounded by Epicurus about 300 B.C., and later elaborated by the Roman poet Lucretius about 75 B.C., in which weight was added to the properties of atoms. In this system there was presented a graphic picture of an

atomically contrived universe in which immutable atoms and the eternal void were provided for the changes in nature and the vicissitudes of life. Thus permanence was combined with incessant transformation. The ideas of the "fortuitous concourse of atoms" in the origin of the world, and of the atomic basis of the freedom of the will, as well as innumerable other applications of Epicurean atomism, are foreign to the present purpose and need no further mention.

The idea of atomism, and specially the necessary provision of a void, was rejected by Aristotle who advocated the principle of the continuity of matter in which a void had no place. Hence began the long contest between the two concepts of continuity and discontinuity, with the former prevailing until the revival of the atomic theory in the seventeenth century. While both ideas are philosophically tenable, the decision between them must be made by exact science. Strangely enough both ideas are incorporated in the modern concept of the atom. For while discrete atoms certainly exist, their electronic constitutents are now seemingly proved to have a wave structure, and therefore they must be continuous with the medium of which they are essentially a part.

The beginnings of atomic theory therefore took three forms: Democritean, geometrical, and Epicurean atomism. From none of them could an atomic bomb be developed. The contribution of ancient philosophers was necessarily limited to the origination and analysis of ideas, and in this they were successful. They suggested both continuity and discontinuity of matter, voids for atoms to move in, the porosity of matter, the motions, weight, and forms of atoms, and the association of number with them. Modern science has verified and given precision to these concepts, but has added to them the divisibility of the atom into constituent particles, and its inner porosity. The fantastic and meaningless forms given to atoms by Plato have been superseded by many definite configurations of their parts held together by forces in dynamic equilibrium.

In the course of six hundred years the arguments for atomism had all been stated and interest in it languished. The concept passed from philosophy to ancient medicine. But Galen, whose

reputation as a physician was second only to that of Hippocrates, finally rejected it as impossible of reconciliation with the phenomena of living organisms. No such idea was anciently propounded as that lifeless atoms could assemble in molecules of living protoplasm. So with the death of Galen about A.D. 200 atomism passed almost into oblivion, until some fifteen centuries later when it was restored to scientific thought.

Medieval Atomism

Throughout the long period of the Middle Ages until the time of Descartes, who published his *Le Monde* in 1633, atomism remained an outcast from philosophy, except for an occasional remark by some writer who generally, like Sir Francis Bacon, condemned it. But the idea did not lose its vitality, and as physical science slowly revived, the atom was inevitably fitted into the foundations. Descartes made corpuscles, as atoms for a time were called, the basis of his natural philosophy of the world, which held its ground for about a century until superseded by the grand system of Newton. His whirling universe was a corpuscular continuum without voids, and so he restored atomism by adroitly conforming to its opposing principles. In the absence of the knowledge of immaterial forces of attraction, which were introduced by Newton, the atoms were still supposed to be held together by clutching mechanisms, such as branching, hooking, wedging, pinning, and even glueing. In their abortive efforts to transmute substances like lead into gold, the alchemists seem to have contributed nothing to the advancement or clarification of atomism.

In the revival of the concept, the Honorable Robert Boyle (1667), a contemporary of Newton, divided the properties of atoms into two classes: the physical or primary qualities, such as size, shape, number, weight, motion, or rest; and the sensible qualities, or secondary qualities as Locke (1690) styled them, such as color, sound, taste, odor, pain, hotness, and cold, to which atoms in application to the body gave rise. In due time the secondary qualities were relegated as sensations to the mind or brain where they have properly remained, and atomism was set free to develop the physical properties alone.

The subsequent growth of scientific atomism depended, as was realized later, on the knowledge of two factors, the proper definition of an element, and the relative weights of atoms, the former of which was made by Boyle and the latter outlined by Dalton. For the first time an element was correctly defined as a substance out of which nothing but itself can be obtained. More than a century later, in France, Lavoisier (1789), a victim of the Revolution, discarded the four "Aristotelian elements" and prepared a tentative list of thirty-three new ones in accordance with Boyle's definition. Sir Humphrey Davy in 1802 recorded forty-two elements; and though he isolated several additional ones himself, yet, influenced by traditional Greek parsimony, he was much perturbed at their steadily increasing number. Today ninety-two natural elements are known, of which the now famed uranium is the heaviest and last, while two artificially produced transuranic elements, neptunium and plutonium, must now be added to the list. The names of these three elements were adopted by analogy with the outermost planets of the solar system.

The atomic theory of matters was placed on an incontrovertibly numerical basis by Dalton in his works published in 1808-10. Like Lavoisier he made the balance the fundamental instrument of chemistry. In his theory the essential idea was atomic weight which was not measured absolutely in ounces or grams, but only relatively to that of hydrogen regarded as unity, or, is is now done, to that of oxygen as sixteen.

Thus the science of chemistry developed on the basis of the atoms of elements combining in definite proportions to form the molecules of compounds, and of voids between atoms in which their motions could be executed. Though remarkable advances were made in theoretical chemistry, in its industrial applications, and in the relations of atoms to one another as shown by the arrangement of elements according to the Periodic Law, yet the original notion of atomic indivisibility was retained. The fundamental problem remained unsolved as to why atoms differ so greatly in weight and so enormously in properties and yet retain their progressive and recurrent similarities as portrayed in Mendeléyev's Periodic Law. Progress of knowledge and

frustration continued side by side until, at the end of the nineteenth century, the mystery was finally disclosed. But again, out of the atomic theory held down to that date no atomic bomb could have been developed.

Modern Atomism

The modern era of atomism was inaugurated in 1897 by Sir J. J. Thomson, the great physicist of the famous Cavendish laboratory, through the discovery of the electron as a constituent of all atoms. The indivisible atom of Greek philosophy and of nineteenth-century science was at last proved to be divisible; and it is this divisibility, with its startling physical consequences, which has precipitated a crisis in world affairs. As Democritus founded in its broadest sense the atomic age, so Thomson founded the electronic age, and modern atomism.

The new era was preceded by now significant discoveries. If the air is largely, but not wholly, exhausted from a "vacuum tube" (a familiar object in illuminated signs) with two metallic terminals or electrodes, one, the anode, to carry the electric discharge in, and the other, the cathode, to carry it out, very striking phenomena at once appear. From the cathode, streams of rays, the cathode rays, are emitted which excite luminescence on the glass or on a screen placed in the tube, an observation originally made in 1858. These streams of rays consist of electrons travelling at speeds scores of thousand of miles per second. From the anode other streams of heavy particles, first observed by Goldstein, travel towards the cathode, with lesser speeds, but at rates still measured in thousands of miles per second. The cathode rays or electrons are atoms of negative electricity and hence are all alike no matter what is the source. The anode rays are positively charged particles, but not atoms of positive electricity (except in the case of hydrogen), which differ in weight and substance with the gas in the tube. If the gas is nitrogen, the anode rays are atoms of nitrogen which have lost an electron. If the gas is oxygen the anode rays are likewise atoms of oxygen which have lost an electron.

In 1895 Roentgen discovered X-rays, and in the following year radioactivity was found by Becquerel. From the experi-

ments of Faraday on electrolysis in 1833, Helmholtz in 1881 inferred the atomic nature of electricity which was verified by the identification of the electron as the atom of negative electricity. These observations originally appeared to have nothing in common until the discovery of the electron united them in an intricately constituted atom. When the radioactive radiations were analyzed by Rutherford into alpha and beta rays, the latter were found to be electrons. The collision of electrons with a metal target in the cathode-ray tube originated the X-rays. The alpha rays, though positively charged, differed from the positive anode rays, and were found to be helium atoms which had lost an electron.

The alluring process of atom building now began. Since an atom in its normal state is electrically neutral, there must be a positive charge somewhere within it to balance exactly the negative electrons. Rutherford suggested an atom like the solar system in which particles of positive electricity, called protons, formed the nucleus around which electrons revolved like planets around the sun. Atoms differ from each other in the number of planetary electrons, and in the equal number of protons in the nucleus. Since the electrons have a very minute mass, the weight of an atom is centered in the heavy central nucleus. So far apart are the electrons that the Rutherford atom is relatively as "porous as the solar system." The emptiness of matter is an extraordinary discovery of modern atomic physics.

The electrons by themselves are of fundamental importance. They constitute the electric currents in conductors which are the basis of all applications to industry and communication by telegraph and telephone. In radio tubes electrons are essential for the reception of broadcasting, and in photoelectric cells, the popular "electric eye," they find increasing usefulness. In properly designed cathode-ray tubes electrons are the essence of radar, and in other forms of tubes electrons furnish the remarkable X-rays. So widespread are their applications that the period since their discovery may well be called the electronic age.

In 1913, Moseley, a gifted young English investigator, a victim of the unfortunate Gallipoli expedition of the First World War, discovered that an atom should exist corresponding to

every whole number from 1 to 92, which are the atomic numbers of hydrogen, the lightest, and uranium, the heaviest, natural elements known. The atomic number and the atomic weight, or mass number, as it is now often called, are of profound importance in revealing the details of atomic structure.

A remarkable development in atomic physics was made by Sir J. J. Thomson in his discovery that the atoms of an element are not all alike; they differ in atomic weight though not in atomic number. These atoms have the same chemical properties and are known as isotopes, since they occupy, as the word indicates, the same place in the Periodic Table of the elements. Oxygen, for example, exists in three isotopic forms, while tin has ten. In all of the ninety-two elements there are 290 isotopes, which is also the number of different atoms. Two substances whose isotopes are of sensational importance are hydrogen and uranium, each with three. The atomic weights of the hydrogen isotopes are 1, 2, and 3; and those of uranium are 234, 235, and 238. Since water is composed of two atoms of hydrogen united with one atom of oxygen, the six isotopes can be put together in eighteen different ways to give possibly the same number of waters, which are mingled together in ordinary water. One of these, called heavy water, formed of hydrogen isotope number 2, was isolated by Urey in the United States, and has received much publicity from its use in developing the atomic bomb. One isotope of uranium, 235, is the actual substance of which the bomb is composed.

Another discovery of outstanding importance is that of the neutron by Sir James Chadwick. The neutron is an uncharged or neutral particle of about the same mass as the proton, which is now believed to be a constituent of all atoms except the first hydrogen isotope of unit atomic weight.

The constitution of the atom as modernly conceived may now be stated. Hydrogen of atomic number 1, and of atomic weight 1, consists of one planetary electron revolving about a nucleus of one proton. Hydrogen of atomic number 1 and atomic weight 2, has one electron and a nucleus of one proton and one neutron. Hydrogen of atomic number 1 and and of atomic weight 3, has still one planetary electron and a nucleus of one proton with

two neutrons. The increasing number of neutrons in the nucleus changes the atomic weight but not the atomic number. In uranium of atomic number 92 and atomic weight 238, there are ninety-two planetary electrons and in the nucleus ninety-two protons. But since the atomic weight is 238, there must be $238 - 92 = 146$ neutrons to account for it. In the isotope, uranium 235, there are the same number of electrons and protons but only 143 neutrons. Similarly from the atomic number and weight the constitution of all atoms can be ascertained.

These combinations of particles in most of the 290 atoms at present known are very stable and can only with difficulty be disturbed. But in atoms of the highest atomic weight, such as those of radium, uranium, and a few others, conditions of limited instability prevail and spontaneous disintegration occurs which gives rise to the phenomena of radioactivity. Planetary electrons occasionally fly off from the atom with enormous speeds and are called beta rays. Groups comprising two protons and two neutrons—the helium nucleus—for some reason sponstaneously split off from the massive nucleus, and because of the powerful repulsive forces stream rapidly away as alpha rays with velocities as high as 18,000 miles per second. The nucleus also emits gamma rays which are very short and highly energetic X-rays. Thus an atom of radium is a powerful X-ray tube. If these rays strike the flesh too long or too powerfully, destruction or "burns" occur which never heal.

In 1919 Lord Rutherford successfully attacked the problem of the artificial disintegration of the nucleus by bombarding nitrogen gas with high-speed alpha particles from a radium product. Occasionally a collision occurred, about once in a million times, with the result that a proton was split off from the atom. This experiment inaugurated the nuclear age of atomism, which has directly led to the production of the atomic bomb.

A notable advance was made by Rutherford's pupils, Cockcroft and Walton, who for bombardment used protons as projectiles to which the necessary high velocities were given artificially by electrical transformers. This experiment opened the way for the invention of other types of instruments of an exceptionally ponderous and expensive character by which electrons

and protons could be given speeds almost comparable with the limiting velocity of light. These giant devices, such as the cyclotron, chiefly developed in the United States, are popularly known as "atom smashers," a term which seems to the writer highly objectionable. For smashing anything suggests reducing it to a shapeless ruin, whereas the nuclear disintegrations which they produce are orderly, if sometimes violent, disturbances which in all cases can be represented by nuclear equations. It would be difficult to represent by an equation an automobile after a collision.

Early in this century (1905) Einstein proposed his famous equation, $E = MC^2$, which shows the equivalence between the energy, E, of any substance and its mass, M. This relationship involves the velocity of light, C, which is the enormous quantity of 186,000 miles or 3×10^{10} centimetres per second. As this quantity is squared in the equation, it reaches the colossal magnitude of 9×10^{20}. The equation means that if a piece of matter is transformed into energy, it ceases to exist as matter and appears as energy in the form of heat, the greatest that can be imagined in nature. It is true for all matter, and, while including atoms of uranium, is not confined to them. As much energy can be derived from the transformation of a pound of earth or butter as of a pound of uranium. What must occur in every case is the disappearance of the matter and the simultaneous appearance of the equivalent energy. Both cannot exist at the same time. One pound of any kind of matter when transformed into energy will give 15,270,000,000 horse-power hours, or 11,400,000,000 kilowatt hours. The kilowatt hour is the unit by which we purchase electric energy for lighting our homes. No method is known by which the transmutation of mass into energy can be artificially effected. It occurs spontaneously in only two substances at present known, one of which is the isotope, uranium 235, and the other a new, artificially produced element, plutonium, of atomic number 94, which is obtained from uranium. The transformation is naturally accompanied by an almost instantaneous process known as a chain reaction which was discovered, and misinterpreted, by Hahn in Berlin, but correctly interpreted by Dr. Lise Meitner in Germany who also discovered

its occurrence in U-235. The anti-Semitic fury of Germany com pelled her to escape from that country, and she was able to giv the information to the Danish physicist, Niels Bohr, who es caped from Denmark to England. Thus this all-important dis covery was removed from Germany and placed at the disposa of the British and American physicists From it came the atomi bomb. It may indeed be the case that the racial hatred of Hitle in the end cost him the loss of the war.

In the chain reaction a neutron strikes an atom of U-235 an divides it into two massive parts which appear to be barium, a metal of atomic weight 137, and the rare gas krypton of atomi weight 84, and at the same time releases two or three other neu trons from the atom. This process is known as fission. Since the isotope of uranium has an atomic weight of 235, and those of barium and krypton are together equal to 221, to which must be added the weight of three neutrons, making 224, the shrink- age results in the loss of mass equal to 235 — 224 or 11 units. This is the amount of mass which is transformed into energy. In one pound of U-235, the loss of weight through fission is only one one-thousandth of a pound; but this is suddenly trans- formed into 11,400,000 kilowatt hours of energy, which is equivalent to that produced by burning three million pounds, or 1,500 tons, of coal.

The released neutrons collide with neighboring atoms and the process of fission is repeated and spreads almost instantan- eously through the whole mass of the isotope 235. The chain reaction does not occur in U-238. For fission to continue, it is essential to have a sufficiently large mass of uranium 235 or of plutonium. In too small a mass it stops through loss of neutrons. As U-235 is mixed with ordinary uranium 238 in the low pro- portion of one pound of the former to 140 pounds of the latter, it is essential that it should be separated, and that is the carefully guarded secret process. Sufficient U-235 or plutonium is an atomic bomb. If two or more sub-critical quantities of U-235 are placed by themselves in the bomb, and at the decisive moment are suddenly thrown together, enough stray neutrons in the air start innumerable chain reactions which of themselves sweep through the mass producing a colossal release of energy.

If the equivalent energy produced by 1,500 tons of coal were gradually released by burning one ton a day, it would take over four years. In the atomic bomb this quantity of energy for each pound of material is released in a minute fraction of a second. The concentrated heat energy therefore raises the temperature to hundreds of millions of degrees, the light is for the moment far brighter than that of the sun, and the out-rushing air-blast has a pressure and a temperature which probably no structure can withstand within a mile or two of the explosion. This energy is the greatest known to science and it cannot be exceeded except by increasing the number of atoms disintegrated. In this way only can bombs of increasing destructiveness be constructed. If fission through chain reactions could occur in any other substance, it also would be equally effective as an atomic bomb.

Atomic energy of this type has no place in the Democritean and medieval concepts of the atom. It is associated with the modern atom only because of its divisibility and electronic and nuclear structure . . .

Some effort to assess the human significance of atomic energy is made by Norman Cousins in his enlarged editorial, *Modern Man is Obsolete.* That the present world civilization has long been on the decline and is now perilously facing catastrophe is evident. But it is equally clear that, apart from the sudden menace of destructive atomic energy, a new world-order is arising which in large measure is due to science. World communication now embraces the whole globe. World transportation is so swift that no two places on its surface are more than sixty flying-hours apart. Despite its division into many races, nations, and languages, the world has become a geographic unit. Business and finance recognize this fact, and the great corporations and cartels divide the world among them without the least regard for national boundaries or sentiment, except that each unit secures its own country for exploitation by itself To dominate this world-order was the aim of Germany. While this attempt has been defeated at frightful cost, the new world-era is still before us. There are minds so obsessed with the past that they are incapable of receiving so enlarged and elevating a concept.

Fearful of and antagonistic to the new, they cling tenaciously and despairingly to the old. These are isolationists. Perhaps it is because of this age-long spirit that a new era is always ushered in with violence. The "modern" man of five centuries ago (that is, his concepts) was obsolete when the ancient world was finally obliterated by the fall of Constantinople. But new world movements, the revival of learning, the Reformation, the era of geographical discovery, the rise of science, the Industrial Revolution, political freedom, soon began to manifest themselves; they have continued to the present time and are now expanding into the new era. Indeed it is the movements then beginning that are now unfolding a still grander world-order into which man is precipitated by the release of atomic power. The stern analogies of history indicate that catastrophic change is the precursor of a new age. Forces of destruction, both human and physical, are now in existence on a scale of an immensity hitherto impossible and unimaginable, and they will, it can scarcely be doubted, shortly engulf the world; but out of the confusion and violence it will emerge into a new order. It is not man that is obsolete, it is his concepts. Given sufficient time, the new age could gradually be established. But time is not available; or perhaps it would be more accurate to say that the time which was available has been uselessly frittered away until probably insufficient now remains. Education can do nothing to ward off the threatened upheaval, for education has created the menace. Nothing is apparent to show that the world is in the least susceptible to a religious appeal. And so catastrophe still is the likely prelude to the new world order. Perhaps future generations will see more clearly than is possible for us that catastrophe was necessary to remove the evils of a grand but perishing age and to select the nations that were worthy to construct the new world order.

The development of the atomic era from its inception by Democritus to the present crisis is of singular interest when contrasted with the succession of empires of "diminishing glory but increasing strength" which constituted the ancient world. It must not be supposed that there is any connection whatever between the theory of atomism and the course of empire, for the

builders of kingdoms knew nothing of and cared less for the concepts of science. But the parallelism serves to show the permanence of correct ideas in contrast with the transitory nature of political affairs.

When physical science, including the doctrine of elements, was founded by Thales (600 B.C.), the first and most glorious of world empires, the Babylonian, was dominant. When atomism was proposed by Democritus (420 B.C.) the Medo-Persian Empire had succeeded to its power. While the foundations of atomistic philosophy were under discussion by Plato, Aristotle, and Epicurus, the Macedonian Empire was rising into preeminence. When Lucretius (75 B.C.) gave to atomism its highest ancient development, Rome had established its sway over most of the known world. The rejection and decline of atomism initiated by Galen (A.D. 200) paralleled the beginning of the decline of the Roman Empire at the accession of Commodus (A.D. 185), while the extinction of that Empire and of the ancient world order by the fall of Constantinople (1453) inaugurated world movements which brought atomism into scientific thought afresh. The rise of modern countries parallels the increasing importance of the atomic theory. Spain passed the climax of her power when atomism began to flourish. The recognition of the elements of matter in France by Lavoisier, executed in the Revolution because the "Republic had no need of chemists," came just when the Bourbon dynasty was extinguished in blood. The ascendancy of the Anglo-Saxon people, the founding of the British Empire and of the United States, and the progressive geographical discovery of the world have paralleled the establishment of the atomic empire of science. The two attempts of Germany to attain world domination came when the divisibility of the atom was achieved, and the electronic and nuclear eras of the atomic age were founded. The world war just won by the United Nations was, as it now appears, a race for the discovery of the release of atomic energy by the opposing powers. It is a remarkable coincidence that military victory came simultaneously with the victory over nature by science. The significance of the atom had been brilliantly and tragically established. The future is uncertain. But it seems assured that the uncontrolled release

of atomic energy will in large measure decide the future dominant power of the world; while its ultimate controlled release will mightily help to complete the emancipation of mankind from unending and hopeless toil, and free the mind and spirit for the high purposes for which they were clearly designed.

THE NATURE OF THE ATOM [2]

The structure of matter preoccupied man long before the beginning of systematic natural science. His interest grew out of philosophical reflection, out of the need to introduce into a world of changing phenomena a principle of order. As early as the twelfth century B.C. the Hindus developed a kind of atomic theory, according to which matter was composed of tiny particles separated from one another by empty space. These particles were supposed to attract one another strongly, and thus was explained the resistance offered by any solid body to being divided. A considerable theoretical advance was made by Democritus and Leucippus, according to whom the particles themselves were indivisible (hence the name atom) and in rapid motion. The Greek philosophers even advanced the view that various substances differed from one another only in the number and arrangement of the atoms composing them. Although this Greek view seems quite close to present-day ideas, it was founded solely on philosophical considerations and led to no advance in factual knowledge.

The atomic theory could become fruitful for chemistry and physics only after England's Robert Boyle (1627-91) and John Dalton (1766-1844), on the basis of careful experimental investigations, gave clear definitions of the concepts of atom and element. According to Boyle, the basic substances or elements are those which, like lead or mercury, are not composed of other substances and cannot be decomposed into other substances. He also established the fact that all decomposable substances are chemical compounds of two or more elements. Dalton showed

[2] By Lise Meitner, Austrian Scientist and Mathematician, whose research in atomic physics contributed materially to the development of the atomic bomb. *Fortune.* 33:136-44+. March 1946.

that when two chemical elements unite to form a compound, they always do so in definite proportions. For instance, any amount of hydrogen always combines with eight times its weight of oxygen to form water, regardless of the amounts of hydrogen or oxygen present.

From this fact Dalton deduced that every element consists of invisibly small, indivisible units, or atoms, and that all the qualities of a given element are present in its atoms. Therefore there must be as many kinds of atoms as there are elements. One or several atoms of one element can chemically unite with one or several atoms of another element. The smallest unit of the new compound is called a molecule, which thus consists of at least two atoms. Two atoms of hydrogen and one atom of oxygen form a molecule of water. Since these elements combine in the ratio of one part to eight by weight, one atom of oxygen must be sixteen times heavier than one atom of hydrogen.

The ratio of the weight or mass of an atom of any element to the weight or mass of the hydrogen atom is termed its atomic weight. Thus oxygen's atomic weight is sixteen. If we know the mass in grams of a single atom of just one element, we can calculate the masses of the atoms of all elements on the basis of their atomic weights. Since the atoms are invisibly small units, their masses are, of course, inconceivably small. This means that any weighable amount of an element must contain an extraordinarily large number of atoms. We have various methods of determining that number. One gram of gold contains a number of atoms that can be represented roughly by the figure three followed by twenty-one zeroes (this comes to about three thousand billion billion atoms).

An approximate idea of the size of an atom can be obtained as follows. By measuring the radius of a soap bubble, we can calculate the area of its spherical surface. After bursting the bubble we can determine its weight, and thus the thickness of the film. Such calculations show that soap bubbles are sometimes less than one-millionth of a centimeter thick. Since the bubble must consist of at least one layer of soap molecules, these molecules must have diameters smaller than one-millionth of a centimeter. And the atoms composing the molecules must be even smaller.

There are ninety-two different elements, and they can be arranged according to chemical properties in what is called the periodic system of the elements. In first place is the lightest element, hydrogen; the system ends with the heaviest natural element, uranium, in ninety-second place. Each element consists of specific atoms. If the atom is the ultimate indivisible unit of matter, it seems impossible to transform one element into another. In any case, to most chemists of the nineteenth century the great successes of chemistry seemed completely to justify abandonment of the alchemists' old dream.

But fundamental ideas develop according to laws of their own. The periodic table strongly suggested the existence of systematic connections among the elements that seemed to contradict the assumption that they were completely independent of one another. As a result, the real existence of atoms was by no means generally accepted, even though in the course of the nineteenth century the theory received several confirmations from physics One of the most zealous advocates of the atomic theory was Ludwig Boltzmann, who taught theoretical physics at the University of Vienna when I began my studies there in 1902. He explained to us with great enthusiasm the significance of the concept of the atom, and spoke with deep gratitude of the experimental proof of the existence of atoms that had been supplied by the discovery of radioactivity. That this proof would revolutionize the very concept of atoms he never suspected.

The new development had begun in France in 1896 with Henri Becquerel's discovery that substances containing uranium emit invisible rays capable of blackening photographic plates and of transforming gases such as air (normally nonconductors) into electrical conductors by splitting the gas molecules into electrically charged positive and negative atoms (so-called ions). Thorough investigation of these phenomena, first by Pierre and Marie Curie in France, then by Ernest Rutherford and his school in England, and by his disciple, Otto Hahn, and many others in Germany and elsewhere, led to surprising discoveries. There began a series of theoretical and experimental investigations destined to change our entire conception of the world.

Mme. Curie discovered that all uranium ores contain a new element that emits much more intense rays than uranium; she

named it radium. It occupies the eighty-eighth place in the periodic table. A number of other elements were discovered in uranium ore, all radioactive—that is, with the property of emitting rays. It was shortly discovered that these rays are of three general types, which, while their true nature was still unknown, were named for the first three letters of the Greek alphabet—alpha, beta, and gamma. Further research showed that only the gamma rays were undulatory like light or X-rays. The alpha and beta rays were shown to be, in reality, material particles that fly out of radioactive elements at such extraordinary speed (some almost as fast as light) as to share the characteristics of rays. The alpha rays are atoms of helium with a double positive charge (i.e., doubly ionized). Helium occupies second place in the periodic table. The beta rays are identical with such negatively charged electrons as occur, for instance, in radio tubes.

Alpha and beta rays possess enormous energy because of their great velocity—more than 20,000 to 100,000 times greater than that of the fastest projectiles. Hence by using extraordinarily refined measuring instruments, it is possible to trace a single alpha or beta ray by its effects, much as a ski track on freshly fallen snow reveals the course of the skier. Thus, in a sense, nuclear particles are made "visible."

The statement that radioactive substances emit alpha and beta rays, or particles, is identical with the statement that these substances are not stable elements. For if an element ejects particles, it must undergo a change—a change into another element. For instance, radium sending out alpha rays decays from a metal into a gaseous element called radon. Radon in turn, by the emission of alpha rays, is transformed into a new element, and so on. Uranium, which emits alpha rays, is in the end transformed into the stable element, lead. This occurs through a number of intermediate stages, the material of each of which turns into the next by the emission of either alpha or beta rays. In this process, each radioactive element is characterized by a definite rate of transformation. Half of any given amount of radium, one of the radioactive intermediates, is transformed into radon in the course of sixteen hundred years. Half of any given amount of radon is transformed into its next product in 3.8 days. These periods

are called half-lives, and vary from element to element. It was also found that thorium undergoes similar changes.

Since a given element consists entirely of atoms of a single kind, it follows that the uranium atom, through the formation of various unstable intermediate atoms, changes into a stable lead atom. This proves that the atom is not indivisible. It must, then, be built of simpler components.

The discovery of this surprising fact became the starting point of the tempestuous development of atomic (and nuclear) physics since the turn of the century.

It led naturally to the question: what then are the ultimate and indivisible constituents of matter? If uranium, through various intermediate stages, is transformed into radium and finally into lead, the atom of uranium must contain the elementary particles from which all these elements are built. The idea was not new that the atoms of all the elements are composed of identical elementary particles and differ only in the number and arrangement of those particles. But only the discovery of radioactivity enabled physicists to study atomic structure experimentally by observing the behavior of the extremely speedy alpha particles as they passed through gases or solids.

The alpha particles act as a kind of atomic probe. It is possible to study their interaction with the atoms of the substance through which they pass, and to draw therefrom conclusions regarding the atom's constitution. We can follow a single alpha particle's path and observe what happens when it collides with atoms of various kinds. Knowledge acquired through such experiments during 1911, 1912, and 1913 led to the conception of the atomic model by Rutherford and Niels Bohr, the Danish physicist.

Before describing this model we need a few words about the nature of electric charge. It, too, has an atomic structure. There is a basic unit of electric charge whose magnitude, independent of its positive or negative sign, can never be decreased. It is indivisible, and any electric charge is a whole multiple of it. If this unit is positively charged, it cannot be combined (except in a special case that we may ignore here) with a smaller mass than the mass of the lightest atom, hydrogen. But if the charge

is negative, the smallest mass occurring as the bearer of this unit has only one eighteen-hundredth of the mass of an atom of hydrogen. This negatively charged unit is called an electron, and has a radius fifty thousand times smaller than that ascribed to the hydrogen atom. The cathode rays appearing in discharge tubes (such as those used in television and radar) are electrons in rapid flight.

Positive and negative electric particles and their mutual attraction must play a decisive role in the structure of the atom. On the other hand, ordinary matter is nonelectric, and normally atoms, too, are nonelectric. That is, they contain an equal number of positively and negatively charged particles.

These facts and the experiments with alpha particles led to the following picture, first conceived by Rutherford in 1911. Each atom consists of a positively charged nucleus in which is concentrated almost the entire mass of the atom. Around the atomic nucleus move as many negative electrons as the nucleus contains positive charges. The number of positive unit charges in the nucleus is equal to the number denoting the place of the given element in the periodic table and is, therefore, termed the element's atomic number. The hydrogen atom, occupying first place, is composed of a nucleus with a positive charge of one, and one electron circling around the nucleus. Helium, in second place, has a nucleus with a positive charge of two, and two electrons circling its nucleus. And so on, up to the ninety-second and heaviest element, uranium, built of a nucleus with a positive charge of ninety-two, and ninety-two surrounding electons.

An alpha particle is simply a helium nucleus—that is, an atom of helium (radial magnitude equals a few hundred-millionths of a centimeter) that has lost both of its planetary electrons and is moving with great velocity.

Experimental studies of the collisions of alpha particles with atoms showed that positively charged alpha particles are occasionally strongly diverted from their straight paths by the repulsion of positively charged nuclei in the atoms. The extent of deflection can be measured. Repulsion forces between electric charges of a single sign (positive or negative) are known. Thus it can be inferred that to bring about strong deflections of alpha

particles, collision between them and atomic nuclei has to take place in an extraordinarily small space, about ten thousand times smaller than the atom's radius. But this is possible only if the radii of colliding atomic nuclei are about ten thousand times smaller than the radii of the atoms.

Conceived as a sphere, the atomic nucleus thus has a volume one thousand billion times smaller than that of an atom. The ratio of magnitude between an atomic nucleus and an atom corresponds more or less to that between a grain of sand and the interior space of Vienna's Cathedral of St. Stephen. The size of the atom is determined by the distance of the outside shell of electrons from the atomic nucleus. Compared to this distance the size of the electrons themselves is negligible.

As we have said, all the qualities of an element are determined by the magnitude of the positive charge of its atomic nucleus. The atomic nucleus of the simplest element, hydrogen, is the bearer of the positive unit charge. Hence the hydrogen nucleus is one of the elementary particles of matter. It is called a proton. The nucleus of an atom of hydrogen contains one proton, that of an atom of helium two protons, and so on up to the nucleus of an atom of uranium, which contains ninety-two protons. But if the atomic nuclei were built only of protons, their atomic weights would have to equal the number of protons they contain. In reality the atomic weights are much larger. For instance, oxygen occupies the eighth place in the periodic system; hence it contains eight protons. But its atomic weight is sixteen. Thus nuclei must contain, in addition to protons, other elementary particles that, while contributing considerably to mass, leave electric charge unchanged. These particles, being electrically neutral, are called neutrons.

In the course of artificial transformation of elements (see below), neutrons were spit off from the atomic nuclei and their masses determined. The mass of neutron proved almost exactly equal to the mass of an atom of hydrogen. The number of neutrons present in an atomic nucleus is therefore equal to the difference between the atomic weight and the number of protons it contains as indicated by its place in the periodic table. Given the atomic weight and atomic number of an element, we can at

once indicate the number of protons and neutrons that form its atomic nuclei. The nucleus or ordinary hydrogen contains one proton and no neutrons. That of helium, second in the table with an atomic weight of four, must be composed of two protons and two neutrons. Uranium, in ninety-second place with an atomic weight of 238, must have an atomic nucleus composed of ninety-two protons and 146 (238 minus 92) neutrons.

The fact that such a large number of particles compressed within the minute space of the atomic nucleus constitute a stable structure shows that extraordinarily strong forces of attraction operate among them. The electrons are maintained in the atom in a certain equilibrium by the electrical attraction of the nuclear protons and by the centrifugal forces arising from the rapid motion of the electrons around the nucleus—though compared to the dimension of the nucleus, the electrons are very distant from it. These electron forces, however, are much smaller than those within the atomic nucleus itself.

The protons, neutrons, and electrons are the ultimate constitutents of matter. The truth is that an element—although we continue to call hydrogen, uranium, lead, and so forth by that name—is not an element at all. It is a complex structure and, as such, further divisible.

A stable atomic nucleus can contain, at most, ninety-two protons; beyond uranium there are no natural stable elements. Is there a similar simple limitation of neutrons whose number (together with the number of protons) determines an element's atomic weight? All nineteenth-century chemists believed that each element had a certain characteristic atomic weight. In terms of modern atomic theory, this would mean that a given number of protons could form a stable nucleus only with a definite number of neutrons. This proved false.

Atomic nuclei, which contain a definite number of protons and thus belong to a particular element, can have a number of neutrons varying within certain limits. Atomic nuclei of a given element can, therefore, vary in atomic weight. For instance, in addition to the ordinary hydrogen atom, whose nucleus contains only one proton, there is the so-called "heavy" hydrogen atom with a nucleus composed of one proton and one neutron, and

with almost double the atomic weight. Most elements are mixtures of atoms of somewhat varying weights. These variants are called isotopes, because, belonging to the same elment, they occupy the same place in the periodic system. Water always contains a small fraction (.02 per cent) of heavy water, whose molecules contain heavy hydrogen.

The existence of isotopes proves that atomic weight does not possess the significance once ascribed to it. It is not a characteristic constant of the *element,* but rather of the atomic *nucleus.* From this weight we can determine a very important magnitude, namely, the work or energy that must be consumed to decompose an atomic nucleus into its constituents or, inversely, the energy that would be released were an atomic nucleus to be built up from protons and neutrons.

To explain this it must be recalled that mass is only a particular form of energy that can be transformed into thermal or electrical energy—as with mechanical energy (or work). The inverse, also, is true: when we increase the energy of a body—for instance, by adding thermal energy (raising its temperature)—we also increase its mass The reason we cannot usually detect this increase is simply that mass represents an extraordinarily great reservoir of energy. (A mass of .001 of a unit of atomic weight (that is, one thousand times smaller than the mass of a hydrogen atom) represents an energy of about one million electron volts or the energy acquired by an electron in moving through an electric field of one million volts. Now, the mass (in grams) of hydrogen atom is represented by a figure that rises above zero only at the twenty-fourth decimal place—only 000000000000000000000002.) Consequently it will be readily understood that in a microscopic body we cannot achieve a *measurable* change of mass by increasing or decreasing energy. The kinetic energy of the fastest projectiles increases their mass by less than a billionth part of the original amount. But changes in mass produced by changes in energy within masses as small as those of atoms are readily ascertainable.

Let us again consider the atomic nucleus of heavy hydrogen. It is the simplest nucleus formed by protons and neutrons, since it contains one of each. We know accurately the masses

of these particles. If mass were an unchangeable magnitude, the mass of heavy hydrogen would be equal to the sum of the masses of proton and neutron. In fact, however, it is smaller by an amount corresponding to energy of about two million electron volts. This energy was obviously given off when, billions of years ago, the atomic nucleus of heavy hydrogen was formed from one proton and one neutron. And we must expend exactly the same amount of energy to decompose this nucleus into its two components. If we form an atomic nucleus of heavy hydrogen by combining one proton and one neutron, we get about two million electron volts of energy in the form of gamma rays.

What we have said about the nucleus of heavy hydrogen is equally true of the atomic nuclei of all stable elements: the mass of an atomic nucleus is always somewhat smaller than the sum of the masses of protons and neutrons forming it. This difference in mass, or as it is usually called, the mass defect, can be easily deduced from the relevant atomic weight. It can be expressed in terms of energy on the basis of the ratio given above. It represents the "binding" energy of the specific atomic nucleus.

The amounts of energy stored up in atomic nuclei are millions of times greater than those we can obtain through any chemical process. Chemical processes affect only the outside electronic shell of atoms. When two atoms of hydrogen and one atom of oxygen combine into one molecule of water, the nuclei remain unchanged; only the arrangement of the outside electrons changes. And since both the distances between electrons and their distances from the atomic nucleus are very large compared with the nuclear dimensions, changes in electron arrangement are connected with energy changes that are relatively slight compared with the energies in play within nuclei. Similarly, all electric, magnetic, and optical processes are confined to atoms' electronic shells and do not touch nuclei. Hence all attempts to transform one element into another by chemical or ordinary physical processes are ineffective.

The transformation of an element requires the transformation of its nucleus. When uranium (via radium) disin-

tegrates into lead, it does so spontaneously. Radioactivity is a property of the atomic *nucleus.* The energies released in this process are now accurately known. When one gram of radium is transformed entirely into lead, the kinetic energy present in the emitted alpha and beta rays would suffice to bring twenty-five tons of water to the boiling point. This energy is about one million times greater than that released by chemical processes. Because radium is transformed very slowly, requiring thousands of years to develop this great energy, the process is not subject to technical control. But the alpha particles of naturally radioactive substances can supply us with energies of several million electron volts.

Rutherford achieved the first artificial transformations of atoms in 1919 by irradiating such substances as nitrogen and aluminum with alpha rays—that is, helium nuclei rich in energy. As a rule these helium nuclei, when coming close to a nucleus of nitrogen, are diverted from their paths. This process is comparable to the clash of two billiard balls. Occasionally the helium nucleus will move directly toward the nitrogen nucleus and approach it so closely that the two nuclei inter-react, just as two clashing atoms react chemically and form a chemical compound. In such a case, the helium nucleus merges with the nitrogen nucleus (positive charge of seven), splitting off a proton. Thus the charge of the nitrogen nucleus is raised by one unit, that is, it becomes eight. And a nucleus with a charge of eight is an oxygen nucleus. The external manifestation is that the proton flies out with great energy and, like a single alpha ray, can be made "visible." Thus we can "see" the transformation of a single atom into a different atom.

The oxygen produced from nitrogen is ordinary stable oxygen. But in the course of such nuclear reactions there can also be formed new atomic nuclei that are unstable, or radioactive. With the emission of rays they change into stable nuclei of a higher or lower atomic number. An instance is the nuclear reaction that occurs when aluminum is subjected to the action of alpha particles, an operation often referred to as the bombardment of aluminum with alpha particles.

Occasionally an aluminum nucleus is hit directly and captures the helium nucleus, simultaneously splitting off a neutron. Since the helium nucleus has a charge of two units and since the split-off neutron is uncharged, the new atomic nucleus must have a charge higher than that of the aluminum nucleus by two units—that is, a charge of fifteen. In the fifteenth place of the periodic table we find the element phosphorus. The bombardment of aluminum by alpha particles thus changes some of the aluminum into phosphorus.

But this phosphorus contains in its atomic nucleus one neutron less than the ordinary phosphorus; it is an isotope of phosphorus, a radioactive isotope, which, through emission of rays, is gradually transformed into stable silicon.

The radioactivity of this artificially produced phosphorus makes it possible in this nuclear reaction to ascertain not only the presence of the neutron that flies out with great energy, but also the newly produced phosphorus. It has all the chemical properties of ordinary stable phosphorus and can be separated from aluminum by chemical methods characteristic of phosphorus. Thus we know that it is a phosphorus isotope.

And although the quantities of radioactive phosphorus produced in such a nuclear reaction are inconceivably small, the fact that it emits rays makes it possible to ascertain its presence, for each emitted ray is observable. The radioactivity of this artificially produced phosphorus isotope was first proved by Irène and Frédéric Joliot in 1934, and thus artificial radioactivity was discovered.

Since the atomic nuclei are built out of protons and neutrons, these will naturally react with atomic nuclei if they can get close enough to them The natural transformation products of the uranium and thorium series supply us with alpha particles that can act as projectiles capable of penetrating other atomic nuclei and therefore of reacting with them. These natural sources of alpha rays are relatively very weak. In the course of the last decade or two it became possible, with large high-voltage sets, and above all, cyclotrons, to produce protons and neutrons of great energy and of intensities incomparably greater than

those supplied by natural alpha-ray sources. As a result, radioactive isotopes could be produced from practically all elements. For instance, we can in this way make gold out of mercury. But such artificially produced gold is an unstable isotope and in the course of a few days is retransformed into mercury.

All these nuclear reactions are characterized by one fact: the newly formed atomic nucleus differs by only one or two unit charges from the original nucleus that entered into a reaction with the impinging neutron, proton, or helium nucleus. Thus any one element can be transformed only into elements occupying nearby places in the periodic table. To produce these nuclear processes we must always expend the kinetic energy of "projectiles," for the nucleus being transformed was originally stable, that is, changeable only by expending work or energy. The process of transformation itself can release either more or less energy than was expended to produce it.

Because of the law of the conservation of energy, the energy gained or lost must correspond to an equivalent change in the store of energy represented by the masses of the atomic nuclei involved in the transformation. In transforming a nitrogen nucleus into an oxygen nucleus, there is a loss of 1,300,000 electron volts. The sum of the atomic weight of the nitrogen nucleus, plus the atomic weight of the helium nucleus that reacts with it, is smaller than the sum of the atomic weight of the newly formed oxygen nucleus and of the split-off proton by an amount that corresponds exactly to the energy lost. In this case, kinetic energy has been transformed into mass. In the transformation of aluminum into silicon through radioactive phosphorus, there is an energy gain of more than two million electron volts, obtained from the masses of the atomic nuclei (aluminum and helium) reacting with each other.

The energy balances of these artificial transformation processes have supplied us with one of the most beautiful experimental confirmations of the equivalence of mass and energy.

In many of these artificial transformations of elements, energies are gained that are millions of times greater than can be supplied in equal amounts by the most energy-rich chemical processes. Yet technical utilization of these energies is impos-

sible because, even under the most favorable conditions, only very small amounts of matter are transformed. The utilization of the intra-atomic energies on a technical scale entered the domain of the possible only toward the end of 1938 when for the two heaviest elements, uranium and thorium, an entirely new process of transformation was discovered. To show the importance of this discovery it is necessary to give some of the background leading up to it.

Fermi discovered that neutrons are a particularly suitable "reagent" for the transformation of elements. Since the neutron has no electric charge, it can come very close to atomic nuclei without being repelled by their positive charges. Of sixty elements investigated by Fermi and his collaborators from 1934 to 1938, forty could be transformed by bombardment with neutrons. The newly formed elements had atomic numbers that were at most smaller by two units or larger by one unit than those of the original elements. When uranium was irradiated with neutrons, one could expect to obtain either the two next lower elements (thorium and protoactinium) or the next higher element (atomic number 93, which does not exist as a stable element).

After Fermi's experiments, Hahn and Meitner (later with the collaboration of Strassmann) continued such investigations in Germany on a broader scale. A whole group of radioactive substances that could not be identical with any of the elements just below uranium in the periodic table was discovered. Only one assumption was possible: they were higher. Therefore they were described as being "transuranic."

Further research led to the discovery that we were dealing with an entirely new process. Hahn and Strassmann found that as a result of the bombardment of uranium with neutrons, there appears an element that is quite low in the table—barium, atomic number 56. *This seemed possible only if the uranium had split into two approximately equal parts.* By taking into account Bohr's view of the structure of atomic nuclei, Frisch and Meitner (who had transferred their work to Sweden) showed that such "fission" processes are to be expected in the

case of the heaviest atomic nuclei, and that they entail a release of almost 200 million electron volts of energy.

In one uranium nucleus, which contains 92 protons and 143 neutrons, [U-235, the isotope of uranium that was found to be fissionable] the forces of mutual repulsion among the positively charged protons are barely compensated by the forces of attraction among all constituents of the nucleus. If a neutron is forced into this atomic nucleus, its energy is increased, and thereby its equilibrium so disturbed that it disintegrates into two parts, two lower atomic nuclei. Since both fragments are highly charged (together they must have a charge of 92 units), they vigorously repel each other and fly apart with energies that, added together, amount to almost 200 million electron volts. This kinetic energy is again supplied by the energy store of mass. The sum of the masses of the two fragments is smaller by an equivalent amount than is the mass of the uranium nucleus after capture of the neutron. The fact that the lower atomic nuclei formed through the splitting of uranium actually possess the energies calculated here was first shown experimentally by Frisch, and then confirmed by others.

Thus the fission of uranium is an artificially produced transformation process that develops about a hundred times more energy than do ordinary nuclear processes.

One other circumstance lends this process particular significance. The uranium nucleus, in addition to 92 protons, contains 143 neutrons plus one added neutron. The nuclei of the lower elements into which the uranium nucleus explodes contain jointly far fewer neutrons. Thus there is a surplus of neutrons, and during the splitting of uranium some are hurled out. These extra neutrons can split new uranium nuclei, again producing neutrons. The splitting process continues multiplying and takes on the character of a "chain reaction." Such a reaction, if it takes place very rapidly, constitutes an explosion. Thus the splitting of comparatively large atomic amounts of uranium releases extremely high energies, and we have at our disposal an energy source of unexampled magnitude, fed by the energy reservoir of mass.

MANHATTAN PROJECT [3]

In the wet blackness before dawn the tall steel tower was invisible. It stood lonely and inert in a flinty wasteland studded with rugged mountains. For dozens of miles there was nothing to be called a town and scarcely a human habitation. In this emptiness of southern New Mexico the hundred-foot structure with the big black ball cradled at its apex seemed curiously out of place. Scores of wires and cables trailed down the framework to a master switchboard near the base and from there undulated away into the darkness. Thousands of yards distant they terminated in a stout timber hut nearly buried in the ground and built behind a massive earthwork bunker. Strangely shaped antennae projected above this bunker and the hut was filled with a confusing assortment of panels, dials, switches and intricately wired apparatus. Before instruments men—some in uniform, some not—waited and watched.

It was nearly 5:30 in the morning. An unseasonable storm had delayed the scheduled time of the test an agonizing 90 minutes. There was intermittent thunder; lightning flashed across the bleak landscape; gusts of rain fell. Over the interconnecting loudspeaker system the voice of the time announcer sounded at the observation stations like an oracle calling the end of the world. "Minus 20 . . . minus 15 . . . minus 10 . . . minus 5 . . ." And in the minds of the anxious persons gathered that stormy morning on that outlandish terrain there was the thought that zero hour might indeed see the end of one world and the birth of a new one. For in the massive ball on top of the steel tower there rested, perhaps, the answer to centuries of wonder and speculation which man had experienced since he first contemplated the sun and the stars. Here was the end result of the boldest, most dramatic scientific venture in history. Here was the top supersecret of the war, the prize at the end of a death race between nations, the object of the wildest political melodrama.

[3] From article by Francis Sill Wickware, Contributor to *Life, Reader's Digest, Scientific American* and other periodicals; formerly on staff of the *New Yorker* and an associate editor of *Fortune*. *Life*. 19.91+. August 20, 1945.

Although many of the witnesses were highly articulate, no one really could describe what happened at 5:30 A. M., July 16, 1945 on the wastelands of the Alamogordo Air Base, 120 miles southeast of Albuquerque, New Mexico. It was a phenomenon unique in human experience. There was an explosion with three phases—first, a light of unearthly brilliance and unearthly heat; second, a violent pressure wave; third, a sustained, awesome, roaring sound. The light, however, was so spectacular that observers were too stunned to pay much attention to the air blast and the sound. "Many times brighter than the midday sun"; "a mountain range three miles from the observation point stood out in bold relief"; "lighting effects beggared description" were a few of the impressions they could frame in words. A huge fiery cloud of many colors rushed 40,000 feet upward, burning away the overcast until it was scattered by the winds of the substratosphere. Six miles from the tower, it was reported an observer who had the temerity to face the explosion suffered temporary blindness and permanent damage to his vision, although he was equipped, like the others present, with special double-thick dark glasses. Near Albuquerque the light flashed across the sky seconds ahead of the sound and a blind girl asked, "What was that?" An El Paso woman driving across the Arizona-New Mexico line 150 miles from San Marcial, the village near Alamogordo, saw the mountains illuminated for about three seconds "exactly like the sun had come up and then suddenly gone down again."

The blast which followed this artificial sunburst knocked down two men standing behind the control hut more than five miles from the tower. The tower itself simply disappeared—probably vaporized by the heat. In its place was a vast crater half a mile wide and a quarter of a mile long. The desert sand in the crater was turned into fused quartz by the heat.

Not until Hiroshima was practically obliterated by a cousin of the New Mexico bomb did the world learn what had been accomplished. Atomic energy, harnessed and unstable, was a fact. The cyclotrons and gamma rays suddenly moved out of the basements of physics laboratories. The "absent-minded" professors with their theories of relativity and interminable formulae

shed their black alpaca coats and overnight donned the tunic of Superman. The weirdly illustrated yarns about rockets to the moon seemed slightly less fantastic now as scientists and philosophers predicted a universal revolution of economics, politics and human customs in the wake of automobile engines the size of a man's fist; power, light and heat so abundant that almost limitless energy would be available; universal private air travel; liners sailing across the Atlantic and back on the atomic energy of a glassful of water; and every conceivable amenity of life distributed cheaply to all the children of the earth. Scientists cautioned that these were no more than possibilities in the elastic future, but nevertheless they were taken seriously. Thoughtful newspaper writers speculated on the coming size and shape of generating plants and took the doleful view that the saving to United States railroads by supplanting coal with atomic energy could not possibly equal the revenue derived from hauling coal, the premise being that coal mining would join the hand loom and the Salem clipper.

But in the days after Hiroshima the only immediate and positive knowledge was that the world had become as unsafe as it might someday become delightful. The Japs themselves acknowledged that they could not even count their dead, much less identify them or tell men from women. Tens of thousands were "seared" beyond recognition by a blast comparable to the one in New Mexico which "vaporized" steel. That was the result of one bomb. It had, according to President Truman and the War Department, more power than 20,000 tons (40,000,000 pounds) of TNT, the equivalent of 2,000 blockbusters or a raiding force of 2,000 Superfortresses. The bomb itself has been estimated to weigh up to 400 pounds. And when it exploded, the released energy was said to be only one tenth of 1 per cent of the total potential energy contained in the explosive. Terrible and destructive as it was, the atomic bomb of 1945 was the mere fetus of atomic bombs of the future. That everyone took for granted—and then took a look into a future where superefficient atomic bombs carried to the ends of the earth by radio-controlled stratosphere rockets might wipe out nations and whole races in a matter of hours. . . .

It is not known just how far the Germans advanced toward perfecting atomic weapons, but their efforts were frantic and the British had good cause to dread the outcome. It was thought that a center of German activity existed at Peenemunde, site of the V-bomb development factories, and during 1943 and 1944 Allied bombers destroyed the installations—also killing, it is believed, several of the leading German atom experts. From the Norwegian underground came word of a mysterious German plant at Rhukan, Norway, which was producing large quantities of "heavy water" which might be used in certain atomic experiments, and with British support Norwegian saboteurs exploded this plant in 1942 after four months of planning. Oddly enough, the questions asked by German agents in the United States enabled our intelligence to keep pretty well abreast of developments in the Reich. For example, the great interest shown by spies in the safety devices of United States atom bomb plants indicated that the Germans were having trouble controlling their processes. Perhaps hopeful of getting a ready-made solution of the whole problem, Adolf Hitler in 1943 issued a special order for the capture of the Danish expert, Dr Neils Bohr. The Danish underground thwarted this, however, and Bohr and his family were smuggled out of Denmark ahead of the Gestapo. He went first to Sweden, taking with him invaluable data on his researches prior to 1940 when he stopped work in protest against the Nazi occupation. Later on a British Mosquito bomber picked up Bohr and brought him to England, where he arrived more dead than alive. . . . Eventually he left England and came to the United States where he joined the army of experts working on the "Manhattan Project." . . .

The atomic bomb is anything but an individual invention. To find the "inventor" of atomic energy would be like finding the original "inventor" of the wheel, or steam, or electricity. The practical application of basic forces in nature occurs when a series of observations are placed in correct order; when the theories of many reach the point of synthesis and reconciliation; when the missing keynote is cemented into the arch. In this case, the basic natural force is that which the sun utilizes to provide heat. President Truman made note of this in his origi-

nal statement when he spoke of "harnessing" the forces of solar energy. For the sun does not burn with an ordinary fire. Its virtually ageless existence, physicists contend, is due to atomic disintegration on a mighty scale. The surface of the sun probably is in a state of constant atomic explosion millions of times more intense than that of any bomb. . . .

The uranium isotope 235, . . . was separated from natural uranium in a quantity barely large enough for experimental purposes in 1941, by Dr. Alfred O. Nier of the University of Minnesota. . . . One of the first experiments with uranium 235 took place in the physics laboratory of Columbia University, New York City, in 1939. There Dr. Fermi, who recently had come from Italy to join the staff, Dr. John R. Dunning and others tested U-235 in the cyclotron. First they bombarded U-238 with a stream of neutrons. Outside the water tanks which surrounded the machine on all sides to absorb dangerous emanations, the recording instruments indicated tremendous bursts of energy being released spasmodically. Dunning and Fermi then removed the U-238 and substituted an almost infinitesimal sample of U-235. Again the cyclotron shot its low-velocity neutron bullets at the targets. This time there were violent and spectacular effects. The instruments chattered and the wavy line on the oscilloscope registering energy given off by the atomic explosions stayed almost constantly at 200,000,000 electron volts. This voltage was produced each time an atom of U-235 was split—and the splitting took place about 10,000 times and more, faster than in the case of U-238. There is almost no way to express this force in comparative terms, but when a pound of TNT explodes it releases only five electron volts per molecule of the mass Thus the energy output of TNT beside that of U-235 would be like an ant beside an elephant. Watching the oscilloscope, Fermi and Dunning knew that the world's destiny was being changed.

After the chain reaction of U-235 had been demonstrated, a group at the University of Chicago, under the direction of Dr. Arthur H. Compton, began to investigate the effects of neutron bombardment on U-238, the isotope whose reaction had produced such a fitful pattern on the oscilloscope at Columbia,

They confirmed that under certain conditions the nucleus of this atom can absorb a neutron from without and when this occurs, a new and heavier isotope is created. This is radioactive and changes into another substance. The investigators called it "neptunium," from the fact that it is beyond uranium—the heaviest natural element—in the table of elements just as Neptune lies beyond Uranus in the solar system But neptunium also is radioactive and in turn changes to "plutonium"—Pluto being beyond Neptune. This new element is highly unstable and when touched off by a neutron "bullet" has a similar chain reaction to U-235. . . . Since it does not occur in nature, plutonium cannot be extracted from ores or other natural sources but results only from the neutron bombardment of U-238. Neutrons are produced in greatest quantity by the U-235 chain reaction and this, rather than cyclotron bombardment, is the novel method used to produce plutonium.

Production of the new element began in 1942 in an ingenious and odd-looking structure called a "pile," shaped like a bathysphere and located on a squash court under the University of Chicago stadium. Here slugs of purified uranium were piled with blocks of graphite and bombarded with neutrons from fission of the U-235 contained in the uranium. The neutrons from this reaction bombard the U-238 in the uranium, changing it to the radioactive substance which becomes plutonium. The purpose of the graphite was to slow down the velocity of the neutrons, for if they move too fast they by-pass the atoms under bombardment Of course, a solid block of uranium treated this way does not immediately become a solid block of plutonium. Not all of its atoms absorb the neutrons, and for that reason plutonium is produced in small quantity and must be extracted from the uranium by difficult chemical processes. Activated slugs from the pile are moved under water to the first of a long series of heavy concrete cells, where they first are dissolved and the plutonium separated through successive operations, with the solution pumped from one cell to the next. The process is governed by remote control and from behind heavy protective shields, since the radioactive by-products are exceedingly dangerous to the human body.

In the ordinary course of events all this would have been the work of decades, but war left no time for leisurely progress. In England and Germany atomic research was mobilized on the most urgent footing. Here, late in 1939, President Roosevelt was advised of the war potentialities of U-235 and appointed a commission to study the problems involved. Its findings led to the organization of the Army's Manhattan Project (so named because of the original Columbia experiment) and to a total news blackout of the entire subject of atomic investigations in general and uranium in particular. . . .

Research was started under government auspices following the report of President Roosevelt's commission, which came within a year after the demonstration of the power of U-235. In 1941 the project had become a major undertaking, and by 1942 it was functioning on a scale nearly unprecedented. In point of speed, numbers of people involved, technological problems surmounted in a wholly new area and dramatic secrecy preserved from beginning to end, the whole project probably is the most impressive industrial accomplishment in the world's history. To establish production, three vast plants with whole cities for workers were created in a matter of months. Two plants were built on a 59,000-acre government reservation near Knoxville, Tennessee. Known as Oak Ridge, this installation had a peak popuation of approximately 75,000 and was the fifth largest city in the state. The third plant went up on a 430,000-acre reservation in a remote section of Washington State and had a population of 17,000 known as Hanford. This was the center of large scale plutonium production in piles similar to the one constructed at Chicago but very much larger. Great heat is generated in these piles, and one reason for the choice of the Washington site (apart from its isolation and abundant power supply) was its proximity to the Columbia River, best source of pure cold river water in the United States. The water is used for cooling the piles, and it is said that below the Hanford plants the Columbia is warmer than above as a result of the enormous discharge of heat.

In addition to the Tennessee and Washington plants, a colossal research center was built at Los Alamos, outside Santa Fe,

New Mexico. Here some 7,000 workers and technicians were employed. In Washington during the construction stage of plants and laboratories the mere words "Manhattan Project" were magic for obtaining the most critical materials in any amount and skilled labor in any volume. But the words were spoken in whispers and never in casual company. You simply did not talk about Manhattan Project or speculate on its purpose. A civilian saying anything about it was likely to be visited at length by Army intelligence and the F.B.I. Officers who showed the slightest inclination toward garrulity suddenly found themselves transferred overseas.

Probably no more than a few dozen men in the entire country knew the full meaning of Manhattan Project, and perhaps only a thousand others even were aware that work on atoms was involved. The whole vast, intricate undertaking was so compartmented and channelized that below top directorial levels no one could see more than a tiny fraction of what was going on, and that fraction never seemed to join with any other. The thousands of men and women in the plants worked like moles in the dark. Their jobs were not explained. The factories were not explained. The purpose of what they were doing was not explained. The end product—if any—was never mentioned. Raw materials by the mountain poured into Oak Ridge and Richland Village, the Washington establishment, but nothing ever seemed to move out. The actual production processes were invisible. Workers stood at dials and switches while behind thick concrete walls mysterious reactions took place. When the news broke after Hiroshima the employes of Manhattan Project were as startled as the rest of the nation. At Oak Ridge, newspapers the day of the announcement sold for a dollar a copy, no change requested or given

Of course, there were rumors. But workers talked little among themselves and less to strangers. "We make bubble gum," they sometimes told inquisitive folk, as one worker told President (then senator) Harry Truman at a congressional probe of alleged waste of manpower on the Richland project. The probe was abandoned almost immediately on General Marshall's urgent request.

The same secrecy extended even to the distant Marianas, where fliers regularly bombing Japan under command of Generals Spaatz and LeMay had no idea that an atomic bomb existed anywhere, let alone that it had arrived in the islands along with a sizable contingent of technicians Even on the historic flight of the B-29 *Enola Gay* to Hiroshima crew members were ignorant of the nature of the mission. Only three men aboard knew what it was: a naval ordnance expert, Captain William S. Parsons; Major Thomas W. Ferebee, bombardier; and the pilot, Colonel Paul W. Tibbetts Jr., who flew over the city at great altitude and turned his ship homeward as fast as he could while a "monstrous" column of smoke erupted from the ground; aerial shocks like flak bursts rocked the plane; and a blanket of boiling brown dust quickly obliterated Hiroshima. Beneath this dust, and in it, lay the complete wreckage of four square miles and the blistered, unidentifiable bodies of countless thousands—an estimated 100,000 instantly killed. All this they would not know until later, but at the moment of the explosion several crew members, long hardened to bombing, exclaimed in horror and wonder, "My God!" The atomic age was born.

THE DISTRIBUTION OF URANIUM IN NATURE [4]

Ordinary uranium is the basic raw material for the production of atomic energy. The only known sources of atomic energy which are of practical significance are the fissionable isotopes, uranium 235 and plutonium 239, both of which are obtained by the processing of ordinary uranium. Since, according to competent authority, this situation will very likely persist for some time to come, an evaluation of the world resources of uranium is of paramount importance to an understanding of the future role of atomic energy. There are two aspects to the problem. The first is the total amount of uranium available, the second deals with accessibility.

Uranium is of very wide distribution in nature. The radioactivity of uranium affords a very sensitive test for its presence;

[4] *Bulletin of the Atomic Scientists.* 1, no. 4:6. February 1, 1946.

consequently innumerable specimens of rock, water, and vegetation have been analyzed for their uranium content. So extensive is the available data accumulated in the last fifty years, that it is possible to answer the question of how much uranium is present in the world with a reasonable degree of certainty. About 95 per cent by weight of the earth's crust consists of the igneous rocks, granite and basalt. The average uranium content of these rocks is 0.004 per cent, or about one seventh of an ounce of uranium per ton of rock. Granite rock, such as constitute the Appalachian Mountains, contains a rather higher proportion of uranium than does basalt; in granite there may be as much as one ounce of uranium per ton of rock. The earth's crust is so heavy that even these very small percentages represent a huge total uranium content. The weight of uranium near the earth's surface has been estimated to be 10^{15} (1 followed by 15 zeros) tons. The oceans also contain minute amounts of uranium, with a total uranium content of about ten billion tons. It is interesting to compare the uranium content to other more familiar elements There is more uranium present in the earth's crust than cadmium, bismuth, silver, mercury, or iodine. Uranium is about one thousand times as prevalent as gold.

While uranium is thus seen to be omnipresent in the rocky portions of the earth's crust, the number of places where uranium occurs in concentrated form is relatively small. Even so, uranium in quantities large enough to be visible to the naked eye has been found on every continent and almost in every country. About one hundred uranium containing minerals have been identified. These occur in quantities ranging from a few isolated crystals to ore deposits estimated to contain thousands of tons of uranium. Of the latter, only four deposits were known before the war Small occurrences have been found in Europe in Sweden, Norway, Germany, Czechoslovakia, France, Belgium, Portugal, Italy, and European Russia. All of these except the Czechoslovakian (St. Joachimsthal) deposits are, as far as is known, either very small, or of very low uranium concentration. In Africa, uranium minerals have been found in Cape Provinces, at Morogoro on the east coast, and of course, in the Belgian Congo, where the world's reputedly richest deposits exist.

Uranium also occurs on Madagascar in amounts which were once considered great enough to warrant commercial exploitation. In the western hemisphere, large deposits are known to occur in Utah and Colorado in the United States, and in the north territories of Canada. In addition there are scores of small occurrences in Ontario and Quebec, and in various parts of the United States (North Carolina, Connecticut, Texas, North Dakota). Uranium has also been found in Mexico and Brazil. Fairly extensive deposits are known to exist in Russian Turkestan and India, and small amounts are present in Australia, New Zealand, and Japan. The actual magnitude of the so-called small deposits is a difficult matter to establish. It is not unlikely that further exploration near the regions known to contain uranium may reveal much larger quantities than had previously been suspected.

Hitherto, the decision to commercially exploit a given uranium deposit was dependent entirely on the costs of producing radium from it. The uranium was strictly a by-product. On this basis, only the Belgian Congo and the Great Bear Lake deposits in Canada have been able to compete in the world market. The deposits at Joachimsthal and in Colorado were unable to do so.

Now, of course, this situation has changed completely. The use of uranium for the production of atomic bombs and for the potential production of power has shifted the interest from radium to uranium. Furthermore, the use of uranium piles will completely eliminate the demand for radium.

From a broad point of view, as much uranium can be obtained as organized society finds worth while. Ores are commonly mined which contain only one fifth of an ounce of gold per ton of rock. Now, vast quantities of rock exist which contain from one fifth to one ounce of uranium per ton of rock. If society decides uranium to be as valuable as gold, then practically unlimited quantities of uranium are available for use in supplying atomic energy. For instance the carnotite ores of Colorado can be made to yield large amounts of uranium.

While uranium at the price of gold may not be able to compete economically with common sources of energy, there is

little question that as far as atomic bombs are concerned, monetary considerations are not pertinent. In the event of an atomic armament race, survival demands uranium, and every country will strain its resources, if necessary, to attain a sufficient supply. Insofar as controls and inspection are concerned, it appears that any country can secure as much uranium as would be necessary for atomic warfare. The problem is whether a country could secure large amounts of uranium without a good probability of detection. This question can best be considered in the light of what is known about uranium deposits.

There are at present four regions in the world where uranium occurs in such quantities that ordinary mining operations suffice to yield considerable amounts of uranium. These are the pitchblende deposits of Canada and the Belgian Congo, the relatively less important carnotite sandstones of Utah and Colorado, and the minor pitchblende deposit at Joachimsthal. In two regions, (Canada and Africa), there is enough uranium to make it possible to obtain one ton of uranium from fifty to one hundred tons of ore. In the other two cases perhaps five times as much crude ore must be mined per ton of uranium. As far as is known, these four deposits are geologically unique. Each one differs from the others, and it is not unlikely that they represent really rare geological phenomena. Even intensive exploration, based on previous experience, will probably not reveal more than a small number of similar occurrences. Their number is at present so small as to render surveillance a rather easy matter.

The situation would be radically different if an attempt was made to use granite as a source of uranium. In order to obtain one ton of uranium, it would be necessary to quarry somewhere between 40,000 and 250,000 tons of rocks. While this is technically feasible, it is an enterprise of such a magnitude as to render concealment impossible. The operations would require a great deal of heavy machinery, large numbers of workers, immense amounts of explosives and chemicals. Extensive transportation facilities and, in general, huge plants would be essential. These could scarcely be hidden.

It thus appears that inspection of uranium mining operation may provide at least a fairly satisfactory mode of control. However there is the possibility of the discovery of very rich deposits, with the resultant ability to obtain large amounts of uranium in an unobtrusive fashion. The only sure way of eliminating this possibility would be an intensive prospecting campaign of those areas of the earth which have as yet received little attention.

CHRONOLOGICAL TABLE [5]

Ca. 400 B. C. Democritus, a Greek philosopher, one of the first to propose an atomic theory.

79 B. C. Lucretius, Roman philosopher, expounds an atomic theory in De Rerum Natura, the greatest philosophical poem of all times.

The atomic theory persisted in the writings of speculative philosophers for many centuries until the time of John Dalton (British), when it first appeared in a form useful to the growing science of experimental chemistry.

1789. M. H. Klaproth (German) isolates from pitchblende a "half-metallic substance" which he named uranium after the planet Uranus, which had recently (1781) been discovered.

1803. Dalton expresses theory that all chemical elements are made of atoms.

1811. Avogadro (Italian) distinguishes between atoms and molecules.

1816. Prout (British) voices hypothesis that all elements are simply various combinations of hydrogen atoms.

1859. Bunsen and Kirchhoff (German) develop spectroscope as an instrument for analyzing light and for studying the chemical composition of incandescent gases.

[5] United States. Senate. Special Committee on Atomic Energy. Essential information on atomic energy, pursuant to S. Res. 179. (Committee monograph no. 1). p. 41-4. 79th Congress, 2d session. 1946.

1871. Mendeleeff (Russian) and Meyer (German) independently develop the periodic table of the elements.

1891. G. J. Stoney (Irish) coins name, "electron," for the elementary particles of electricity.

1895. W. C. Roentgen (German) discovers X-rays.

1896. H. Becquerel (French) discovers phenomenon of radioactivity in uranium ores.

1896. J. J. Thomson (British) studies deflection of cathode rays by a magnet and concludes these rays are actually streams of discrete particles of negative electricity, thus giving evidence for the physical reality of Stoney's electrons.

1897. Rutherford (British) studies radiations from uranium after Becquerel's discovery of radioactivity and designates three types of rays—*alpha, beta,* and *gamma* rays.

1898. Marie and Pierre Curie (Polish-French) discover radium and polonium.

1900. Planck (German) announces the quantum theory that energy manifests itself in discrete amounts called quanta.

Elster, Geitel (German), and Wilson (British) show that a closed ionization chamber demonstrates weak but persistent conductivity. Wilson suggests ionization might be due to radiation coming from outside the earth's atmosphere.

1905. Einstein (German) publishes his "special theory of relativity" which includes the famous equation $E=MC^2$ for the equivalence of energy and mass.

1906. Rutherford and Geiger develop the first electrical instrument for counting alpha particles. This became, through successive refinements, the Geiger counter for detecting atomic particles of various kinds. It is one of the most powerful observing and measuring instruments in the physical sciences.

1910. Millikan (American) begins his classical experiments to measure the exact charge of the electron.

The possibility of isotopes, atoms with different weights but identical chemical properties, is suggested by Soddy.

1911. Rutherford proposes theory of the nuclear atom with its mass and positive charge at its center.

Barkla (British) finds number of electrons on outside of atom by studies on scattering of X-rays.

1912. C. T. R. Wilson (British) devises the modern form of cloud expansion chamber for the visible study of ionized particles. This is another fundamental tool of the nuclear physicist.

Laue, Friedrich, and Knipping (German) demonstrate X-ray diffraction by crystals.

W. H. and W. L. Bragg (father and son, British) develop X-ray spectrometer using crystals as diffraction gratings.

1913. F. Soddy, K. Fajans, and A. S. Russell independently explain laws of radioactive disintegration.

Niels Bohr (Danish) devises model of atom with central nucleus and electrons rotating in orbits about it.

Moseley (British) establishes atomic numbers of the elements through studies of their X-ray spectra.

1915. Einstein announces his general theory of relativity.

1919. Rutherford changes nitrogen into oxygen by bombarding atomic nuclei with alpha particles. This was the first artificial transmutation of an element in history.

1919-32. F. W. Aston (British) devises the mass-spectrograph and uses it to measure the atomic

weights of the isotopes of most chemical elements.

1920. Aston measures the atomic weight of hydrogen with the mass-spectrograph and Harkins (American) suggests the existence of an atomic particle with zero electric charge. He uses the name "neutron" for it.

1922. Boron, fluorine, sodium, aluminum, and phosphorus are artificially disintegrated by Rutherford and Chadwick.

Millikan and his collaborators begin their studies on cosmic rays.

1924. DeBroglie (French) starts quantum mechanics by suggesting existence of waves associated with particles.

1927. Davisson and Germer (American) show that beams of electrons can behave as if they were waves. Their experimental results were in good agreement with DeBroglie's equations.

1929. G. Gamow (Russian), R. W. Gurney (British), and E. U. Condon (American) show that the laws of radioactivity are explained in terms of quantum mechanical behavior of particles in the nucleus.

1930. The positron, a particle of positive electricity, is predicted from theoretical consideration by P. A. M. Dirac.

1931. W. M. Latimer, H. C. Urey, H. L. Johnson, R. T. Birge, and D. H. Menzel (American) construct table of isotopes and predict existence of unknown isotopes. Many of these have already been discovered.

E. O. Lawrence (American) invents the cyclotron.

1932 H. C. Urey, F. Brickwedde, and Murphy (American) discover heavy hydrogen (deuterium).

J. Chadwick (British) discovers the neutron.

C. D. Anderson (American) discovers positron resulting from passage of cosmic rays through matter.

J. D. Cockcroft and E. T. S. Walton (British) find mass converted to energy when the lithium nucleus is bombarded with artificially accelerated protons.

1933. Chadwick, Blackett, and Occhialini demonstrate production of positrons through bombardment of matter with gamma rays.

Van de Graff (American) designs electrostatic generator to produce up to 10,000,000 volts.

C. C. Lauritsen uses million-volt X-ray tube for atomic studies.

1934. E. Fermi (Italian) bombards uranium with slow neutrons and creates new element with atomic number 93.

Irene Curie and F. Joliot (French) produce artificial radioactivity.

1945. Dempster (American) discovers uranium-235.

1939. O. Hahn and F. Strassmann (German) bombard uranium with neutrons and find barium and krypton among the fragments of the uranium nuclei.

Lise Meitner and O. Frisch (German) propose theory that this splitting of the uranium atom, to which they gave the name "fission," is accompanied by the release of enormous quantities of energy.

Frisch and Joliot independently and almost simultaneously demonstrate experimentally that large amounts of energy are actually released as a result of uranium fission

Bohr and Wheeler present early comprehensive theory of nuclear fission. Bohr suggests that uranium-235 undergoes fission.

Meitner studies fission in thorium.

Several American laboratories (Columbia, Johns Hopkins, Carnegie Institution, and California) confirm fission experiments.

Possibility of military uses of energy released by fissionable materials envisaged by L. Szilard, E. Fermi, E. Wigner, and others.

In fall of 1939, Alexander Sachs transmits a letter from Einstein to President Roosevelt suggesting that work on fission be encouraged.

President Roosevelt appoints Advisory Committee on Uranium.

1940. National Defense Research Committee organizes and takes over uranium research project.

Two new elements, neptunium and plutonium, are created and quantity production becomes a definite possibility.

Nier, of Minnesota, and Dunning, of Columbia, independently confirm Bohr's prediction of the fissionability of uranium-235.

1941. Possibilities of using plutonium for a bomb were investigated.

Office of Scientific Research and Development takes over uranium project.

1942. August 13. The Manhattan District of United States Army, Corps of Engineers, is established for the production of atomic bombs.

December 2. The first self-maintaining nuclear chain reaction is put into operation on the campus of the University of Chicago.

1943. April. Laboratory for bomb research opened at Los Alamos, New Mexico.

1945. July 16. The first experimental atomic bomb is successfully exploded in New Mexico.

Augus 6. The first military atomic bomb is dropped on Hiroshima in Japan.

August 6. President Truman issues first announcement on the use of the bomb.

August 8. Second atomic bomb dropped on Nagasaki.

August 11-12. Official report, "Atomic Energy for Military Purposes," by H. D. Smyth, is released to the public.

October 3. President Truman sends message to Congress recommending legislation for domestic control of atomic energy.

November 15. Declaration on atomic energy issued by President Truman and Prime Minister Attlee and Mackenzie King.

December 27. Moscow Agreement announced.

1946. January 24 United Nations Atomic Energy Commission is created.

TABLE OF ELEMENTS [6]

Atomic Number	Name of Atom	Chemical Symbol	Approximate Atomic Weight
1.	Hydrogen	H	1.008
2.	Helium	He	4.003
3.	Lithium	Li	6.94
4.	Beryllium	Be	9 02
5.	Boron	B	10.82
6.	Carbon	C	12.01
7.	Nitrogen	N	14.008
8.	Oxygen	O	16.00
9.	Fluorine	F	19.00
10.	Neon	Ne	20.183
11.	Sodium	Na	22.997
12.	Magnesium	Mg	24.32
13.	Aluminum	Al	26.97
14.	Silicon	Si	28.06
15.	Phosphorus	P	30.98
16.	Sulphur	S	32.06
17.	Chlorine	Cl	35 457
18.	Argon	A	39.944

[6] From International Table of Atomic Weights; with inserts (*) from *Atom*. 1:27. Fall 1945.

TABLE OF ELEMENTS—*Continued*

Atomic Number	Name of Atom	Chemical *Symbol*	Approximate Atomic Weight
19.	Potassium	K	39 096
20.	Calcium	Ca	40.08
21.	Scandium	Sc	45.10
22.	Titanium	Ti	47 90
23.	Vanadium	V	50 95
24.	Chromium	Cr	52.01
25.	Manganese	Mn	54.93
26.	Iron	Fe	55 85
27.	Cobalt	Co	58.94
28.	Nickel	Ni	58.69
29.	Copper	Cu	63.57
30.	Zinc	Zn	65.38
31.	Gallium	Ga	69.72
32.	Germanium	Ge	72.60
33.	Arsenic	As	74 91
34.	Selenium	Se	78.96
35.	Bromine	Br	79 916
36.	Krypton	Kr	83.7
37.	Rubidium	Rb	85.48
38.	Strontium	Sr	87 63
39.	Yttrium	Y	88.92
40.	Zirconium	Zr	91 22
41.	Columbium	Cb	92 91
42.	Molybdenum	Mo	95 95
43.	Masurium *	Ma	
44.	Ruthenium	Ru	101 7
45.	Rhodium	Rh	102.91
46.	Palladium	Pd	106.7
47.	Silver	Ag	107.88
48.	Cadmium	Cd	112.41
49.	Indium	In	114.76

TABLE OF ELEMENTS—*Continued*

Atomic Number	Name of Atom	Chemical Symbol	Approximate Atomic Weight
50.	Tin	Sn	118.70
51.	Antimony	Sb	121.76
52.	Tellurium	Te	127.61
53.	Iodine	I	126.92
54.	Xenon.	Xe	131.3
55.	Cesium	Cs	132.91
56.	Barium	Ba	137.36
57.	Lanthanum	La	138.92
58.	Cerium	Ce	140.13
59.	Praseodymium	Pr	140.92
60.	Neodymium	Nd	144 27
61.	Illinium *	Il	146.0
62.	Samarium	Sm	150.43
63.	Europium	Eu	152.0
64.	Gadolinium	Gd	156.9
65	Terbium	Tb	159.2
66.	Dysprosium	Dy	162.46
67.	Holmium	Ho	164.94
68.	Erbium	Er	167.2
69.	Thulium	Tm	169.4
70.	Ytterbium	Yb	173.04
71.	Lutecium	Lu	174.99
72.	Hafnium	Hf	178.6
73	Tantalum	Ta	180.88
74.	Tungsten	W	183.92
75.	Rhenium	Re	186.31
76.	Osmium	Os	190.2
77.	Iridium	Ir	193.1
78.	Platinum	Pt	195.23
79.	Gold	Au	197.2
80.	Mercury	Hg	200.61

TABLE OF ELEMENTS—*Continued*

Atomic Number	Name of Atom	Chemical Symbol	Approximate Atomic Weight
81.	Thallium	Tl	204.39
82.	Lead	Pb	207.21
83.	Bismuth	Bi	209.00
84.	Polonium *	Po	210.0
85.	Alabamine *	Ab	221.0
86.	Radon	Rn	222.0
87.	Virginium *	Vi	224.0
88.	Radium	Ra	226 05
89.	Actinium *	Ac	226.0
90.	Thorium	Th	232.12
91.	Protactinium	Pa	231.0
92.	Uranium	U	238.07
93.	Neptunium	Np	239
94.	Plutonium	Pu	239

ATOMIC SCIENCE VOCABULARY [7]

1. *Alpha Particle*: a helium nucleus, traveling at a very high speed, which appears when the atoms of "alpha-radioactive" substances, such as radium, polonium, uranium, thorium break down or disintegrate.

2. *Atom*: the basic unit of matter in chemical reactions; no smaller amount of substance takes part in any chemical reaction. The structure of the atom is like that of the solar system in that there is a heavy nucleus analogous to the sun, with electrons rotating about it in orbits as various heavenly bodies like the earth rotate about the sun.

3. *Atomic number*: the number of positive charges (see protons, definition 59) on the nucleus of the atom. This determines the chemical nature of the atom. Atomic number 2 is helium, 13 is aluminum, 29 is copper, 92 is uranium, etc.

[7] Atomic Scientists of Chicago. *The Atomic Bomb: Facts and Implications.* p. 57-60. 1946.

4. *Atomic weight*: the weight of the atom is determined almost entirely by the weight of the nucleus since the electrons in the orbits are comparatively very light. The weight is very nearly equal to the total number of protons and neutrons in the nucleus. The basic unit of weight in terms of which all atoms are described is one-sixteenth the weight of the common oxygen atom, approximately the weight of one proton or one neutron.

5. *Beta particles*: very rapidly traveling electrons given off when atoms of "beta-active" radioactive substances break down or disintegrate.

6. *Binding energies*: the energy which must be introduced into the nucleus of an atom to cause it to release a given nuclear particle (neutron, proton) or component such as an alpha-particle.

7. *Calutron*: a machine for separating the various uranium isotopes (see definition 41) based on the mass-spectrograph principle (see definition 47).

8. *Chain reaction*: a reaction, chemical or nuclear, in which the energy or particles generated by the breakdown of the first atom or molecule causes the breakdown of one or more additional atoms or molecules whose reaction in turn causes other atoms or molecules to disintegrate.

9. *Chemical exchange*: a process in which an atom in one kind of chemical substance exchanges places with a similar atom in a different substance. This exchange is influenced by the relative masses of the two atoms of the same element, and forms the basis of methods of isotope separation and concentration.

10. *Cloud chamber*: device for observing path of individual radiation particle. Track is made visible to eye because fog droplets are formed along the path of particles.

11. *Control rods*: rods of neutron-absorbing material (cadmium or boron steel) used in a pile (see definition 55) to control the chain reaction to a steady level.

12. *Cooling*: a term commonly used for setting aside a highly radioactive material for some time until the radioactivity has reduced itself to a desired level.

13. *Counter*: (Geiger, alpha): instrument for detecting and counting individual radiations such as beta particles, alpha particles, gamma rays, etc.

14. *Critical mass*: the minimum amount of a given fissile (see definition 28) material (uranium-235 or plutonium-239, for example) required for a spontaneous chain reaction. With less than this amount, the rate of escape of neutrons through the surface of the mass is too high to result in a "chain reaction."

15. *Cross-section, nuclear*: apparent target area of a nucleus which is undergoing bombardment by nuclear particles, judged by the number of successful reactions obtained. As this apparent area involves internal factors which determine whether a reaction occurs or not, it is usually different from reaction to reaction.

16. *Cyclotron*: apparatus used to give great speeds to charged particles by accelerating them repeatedly A strong magnetic field keeps the particles traveling in an expanding circular path. These particles are used in nuclear bombardment experiments.

17. *Danger coefficient*: measure of neutron-absorbing power of an impurity element in a pile.

18. *Decontamination*: separation of undesirable radioactive substances from a desired product; e.g., separation of fission product radioactivities from plutonium

19. *Deuteron*: nucleus of heavy-hydrogen atom, used as a projectile in many bombardments with the cyclotron.

20. *Diffusate*: material which has been separated by the process of diffusion (see definition 21). Specifically, material which has passed through a barrier in the barrier diffusion separation method for uranium isotopes.

21. *Diffusion*: the movement of molecules through a gas, liquid or solid, due to the natural motion of the molecules which is a function of their temperature. The higher the temperature, the higher the rate of diffusion.

22. *Disintegration*: the process of spontaneous nuclear change in which a beta particle, alpha particle, or occasionally a positron (see definition 57), is given off from the nucleus, leaving the nucleus with a different atomic number.

23. *Electron*: the unit particle of negative electricity, weighing about 1/2000 as much as a proton. Electric current is made up of a stream of electrons.

24. *Electron-volt*: the unit of energy used in nuclear science. Nuclear reactions usually involve energies of the order of millions

of electron-volts (abbreviation, Mev), while chemical reactions involve energies of only a few electron-volts An electron-volt is equal to the energy of a single hydrogen atom traveling at about 550 miles a minute.

25. *Electroscope*: instrument for measuring radiation by means of the ionization the latter produces in air, this ionization acting to discharge a "condenser" made of two gold leaves or of metal-coated quartz fibers.

26. *Element*: a kind of matter which is not decomposed by any kind of chemical reaction; a kind of atom with a given atomic number, such as hydrogen, aluminum, iron, copper, bromine, chlorine, uranium, etc.

27. *Enrichment factor*: a ratio of ratios; the ratio of concentration of a given desired isotope to that of the other isotopes in the *product* mixture divided by the corresponding ratio in the mixture *before* isotope separation processes are used. Thus, to produce 90 per cent U-235 from natural uranium (1/140 U-235) needs an overall enrichment factor $90/10 \div 1/139$ or about 1,260.

28. *Fissile*. capable of being split; cleavable. Used to describe types of atoms such a uranium, thorium, protactinium, etc., which may undergo fission.

29. *Fission*· the process by which the nucleus of an atom is split into several parts, at least two of which are of roughly comparable size, greater than that of the alpha particle. The process of fission of heavy atoms usually gives two lighter atoms from the middle of the periodic table, together with several neutrons and much energy. Fission caused by a very energetic neutron is called "fast fission," by a slow neutron, "slow" or "thermal" fission.

30. *Fissionable*: see "Fissile."

31. *Fission product*: an isotope (see definition 41), usually radioactive, of an element in the middle of the periodic table and produced by fission of a heavy element such as uranium.

32. *Fractional distillation*: process of separation of one or more components of a mixture of substances with different boiling points by careful boiling off of only part of the mixture.

Properly done, substances may be fairly cleanly separated from each other.

33. *Gamma ray*: penetrating invisible light-like radiation given off from the nucleus of an atom when "excited." Usually more penetrating than ordinary X-rays, which originate outside of the nucleus.

34. *Half-life*: the length of time it takes a sample of radioactive isotope to decrease to half of its original amount by radioactive disintegration. The number is a physical constant characteristic of the isotope, and independent of the particular amount originally present, and of external conditions such as temperature, pressure, etc.

35. *Helium*: second element in periodic table; nucleus is "alpha particle."

36. *Heavy water*: water in which the hydrogen of the H_2O is composed of the heavy isotope of hydrogen, called deuterium, with mass number 2. (See definition 46.) Written D_2O.

37. *Hold-up*: term used to describe the amount of valuable material tied up in processing.

38. *Ion*: an atom or molecule which carries an electric charge.

39. *Ionization chamber*: instrument for measuring directly the amount of ionization radioactivity produces in air, or other gas.

40. *Isobars*: in nuclear science, two atoms with different atomic number but with the same mass number. For example, cadmium-113 and indium-113; neptunium-239 and plutonium-239.

41. *Isotopes*: atoms of a given element which have different numbers of neutrons in the nucleus and therefore differ in mass or weight.

42. *Isotron*: device for electromagnetic separation of isotopes in which the ion source is of large area, rathen than a slit as in the usual mass spectrograph.

43. *Lattice*· the geometrical arrangement of the uranium or plutonium rods in a pile.

44. *Magnetron*: apparatus for electromagnetic separation of uranium isotopes (not actually used in U-235 production).

45. *Mass*: effectively the same in weight.

46 *Mass number*: the number of particles (protons and neutrons) in a given nucleus; approximately the weight of the nucleus.

47. *Mass spectrograph*: instrument for sorting out and registering the masses of atoms and light molecules. This is made possible because the path of an ion in a magnetic field is curved. Particles of different masses travel curved paths of slightly different radii.

48. *Moderator*: material containing atoms of low atomic weight; used in pile for slowing down neutrons by collision. Heavy hydrogen, beryllium, and carbon atoms are good moderators.

49. *Molecule*: a chemically distinct grouping of atoms which cannot be further broken down without changing its nature, e.g., H_2O (water), C_2H_5OH (alcohol), C_6H_6 (benzene), $C_6H_{12}O_6$ (grape sugar), $C_6H_2.CH_3.(NO_2)_3$ (TNT).

50. *Multiplication factor*: the number of neutrons produced for every neutron disappearing in a chain-reaction system (pile). If the factor is equal to one, or greater, the chain reaction proceeds. Where the factor is less than one, the chain reaction cannot maintain itself.

51. *Neptunium*: element number 93, not found in nature but produced artificially. The isotope Np-239 is the radioactive parent of plutonium-239, an atomic explosive.

52. *Neutron*: a nuclear particle, with a weight of about one unit, which is electrically neutral (carries neither a positive nor a negative charge).

53. *Nucleus*: the central core of the atom in which almost all the weight is located. It is situated in the atom as the sun is in the solar system.

54. *Periodic table*: a systematic arrangement of the chemical elements in order of their atomic numbers with groupings of elements in terms of their similarities in properties.

55. *Pile*: a controlled fission chain-reacting system, usually consisting of uranium or plutonium intermixed with a moderator such as graphite, beryllium, heavy water, together with all the neutron reflector, shielding, cooling, and control systems.

56. *Plutonium*: element number 94, not found in nature but produced artificially. The isotope Pu-239 is an atomic explosive like U-235.

57. *Positron*: positive electron; appears in certain decays of radioactive substances and in cosmic radiation.

58. *Protactinium*: element number 91.

59. *Proton*: the atomic nucleus of ordinary hydrogen. It is a component part of atomic nuclei of all other elements. Number of protons in a nucleus determines the nuclear charge (atomic number).

60. *Radioactive equilibrium*: the state which prevails when the amount of a radioactive isotope stays constant because new atoms are being formed at the same rate at which they disintegrate through radioactive decay.

61. *Radiation*: particles, X-rays, gamma-rays, or light moving between or past atoms, and not part of their stable structure.

62. *Radioactivity*: the phenomenon of giving off radiation during the spontaneous disintegration of atomic nuclei.

63. *Reproduction factor*: same as multiplication factor (see definition 50).

64. *Resonance energy*: particular energy of bombarding particle for which nucleus is exceptionally reactive.

65. *Roentgen rays*· commonly known as X-rays.

66. *Separation factor*: same as enrichment factor (see defintion 27.)

67. *Tamper*: special neutron reflector used in atomic bomb.

68. *Thermal diffusion*: method of separation of uranium isotopes depending upon higher rate of movement at given temperature for light particles.

69. *Thermal utilization factor*: fraction of slow neutrons in pile absorbed by the uranium in the pile rather than by the moderator, impurities, fission products, etc.

70. *Thorium*: element number 90.

71. *Transmutation*: the process of changing an atomic nucleus to one of different atomic number or atomic weight by bombardment with nuclear particles from the outside, as in a cyclotron or pile.

72. *Transuranic elements*: elements with atomic numbers higher than that of uranium (number 92). For example, neptunium (93), plutonium (94).

EXCERPTS

If the uranium atom were enlarged a thousand million times, it would be about a foot in diameter. If its weight were increased proportionately to the increase in volume the atom would weigh about a thousand pounds. In the center of this magnified atom we would find a kernel about the size of a minute grain of sand. This is the nucleus. The part of the atom outside the nucleus consists only of electrons—and in the case of uranium there are 92 of them. These electrons are very light particles, and they move around the nucleus in orbits determined by the electrical forces which control them. On our scale of magnification, the total weight of the 92 electrons would be a quarter of a pound, and all the rest of the thousand-pound mass would be in the tiny nucleus. In other words, that magnified kernel, about the size of a small grain of sand, would weigh nine hundred and ninety-nine pounds and twelve ounces. A thimbleful of uranium nuclei would weigh thousands of tons.—*Isidor I. Rabi, Professor of Physics, Columbia University. "Atomic Nucleus", radio broadcast, New York Philharmonic Symphony program. United States Rubber Co. New York.* '46.

It is not at all farfetched, I believe, to remind this committee that the release of atomic energy, through methods comparable with the fission of uranium and plutonium, is the most basic operational fact of the universe, except perhaps for its creation. In announcing the fall of the first atomic bomb in Japan, President Truman referred to this fact that the atomic energy that produces sunshine is essentially the same as the energy of the bomb.

A generation ago the astronomers were forced to hypothecate the release of atomic energy in the hot interior of the sun—forced to it by the fossils in the old rocks of the earth. The

fossil plants of the carboniferous age were discovered to be some 300,000,000 years old This was demonstrated, incidentally, through the normal radioactive transmutation of this same uranium atom, the artificial splitting of which has produced an international headache and a crisis for humanity.

The great age of the fossils which lived by grace of the same kind of sunshine and the same amount of sunshine as works today in preparing us to be the fossils of the future, makes necessary a long-continued constant source of sunlight. . . .

No other source is considered possible than that which arises from the energy of the atoms. The sun has been a steady producer for hundreds of millions of years, and to perform so steadily it has used natural atomic engines.

I should interpolate here that other sources of solar energy have been considered, like the infall of meteors, like the contraction of the sun, like the simple burning of the sun. They all can produce energy for a certain amount of time, but not sufficient energy to keep the earth heated long enough for the geological ages that we now recognize. The sun apparently is not depending on the splitting of uraniumlike atoms. It works at the other end of the periodic table, as Dr. Bethe has already explained to this committee. It gets its enormous energy sources from the synthesis of light elements out of the lightest of all elements—hydrogen. By far the most colossal source of atomic energy in the universe is this transmutation in the stars of this most common of the elements. The stars can do it. We think we know how they do it. And we cannot follow their method because the maintenance of the necessarily high temperature, about 20,000,000, would be difficult if not impossible, and would be impractically expensive. The artificial transmutations of the lighter elements so far accomplished by man require much more energy than is produced. Our methods are not efficient.—*Harlow Shapley, Director, Harvard Observatory. United States. Special Committee on Atomic Energy. Atomic Energy Act of* 1946; *hearings January* 29, 1946, *on S* 1717. *pt.*2. *p.* 162-3.

The story of the making of the atomic bomb is one unprecedented in human history. The problems to be overcome seemed

too great to solve In the first place, even though 200,000,000 electron volts is a tremendous amount of energy for the amount of matter releasing it, it is not much energy even when compared to that from a burning match Millions upon millions of fissions must occur each second in order to have the slightest amount of usable energy.

Then, too, it is not ordinary uranium which explodes with such violence. The common kind of uranium has a mass of 238 (U-238), but it is a scarce isotope having a mass of 235 (U-235) which undergoes fission. Only 1/140 of ordinary uranium is U-235, and it is difficult to separate from the U-238. Remember, these are isotopes, chemically identical, and one cannot be separated from the other by any known chemical method.

Using the mass spectrometer, the first tiny bit of U-235 was obtained in 1940. How much? At the rate then achieved it would take nearly twelve million years to get one pound. How much was needed for a bomb? Calculations showed a minimum of about 2 pounds and a maximum of about 200 pounds. Methods certainly had to be improved. And they were. By the end of 1943, an entire plant was in operation for the separation of U-235 by this same electromagnetic method.

There are a number of other ways of separating U-235. One of these, the gaseous diffusion method, became practical, and by 1945 a large plant for this type of separation was in operation. Here the two isotopes are changed to gases and are allowed to diffuse through a porous barrier, where the lighter U-235 passes through faster than the heavier U-238.

Yes, separating U-235 from U-238 is difficult Early in the race for the atomic bomb no one could tell if it ever could be done on a large enough scale. It was natural, then, for scientists to think about the new atom they had made—plutonium, for they knew that it, too, could be split. Plutonium forms when an atom of U-238 captures a neutron, and U-238 is fairly plentiful. Perhaps there was some way to create plutonium on a large scale

A long series of experiments showed how to do it with a large mass of uranium and graphite called a pile. It is tricky and very dangerous work The gamma rays, neutrons, and other radiations which escape from the pile are death-dealing, so the

pile must be built behind several feet of concrete and steel. No one dares approach an unshielded pile; even the air around it becomes radioactive and poisonous. Then, too, there is danger the pile might explode with disastrous results. Unbelievable amounts of heat are generated by a pile, and some method of cooling it is necessary.

Then there is the problem of separating the Pu-239 after it has been formed in a pile. It is done chemically—all by remote control, behind thick protective shields, until the plutonium is pure.

Of course, there were other problems—thousands of them. But although by the end of 1942 there was in existence only 500 millionths of a gram of plutonium, by 1945 a large plutonium plant was in operation, producing the material on a commercial scale.

More than four square miles, 60 per cent of Hiroshima, Japan, was blown off the face of the earth on the morning of August 6, 1945—all by a single bomb, from the change of a small bit of matter into seething, undiluted energy. They tell us, in simple, cold figures, that the early bombs were inefficient and have already been improved upon. Only about one tenth of 1 per cent of their active mass was changed into energy. For every pound of U-235 which exploded, 0.999 pound of material remained, and only 0.001 pound of the mass was converted into energy. If the entire pound of U-235 (or any other mass) could be changed into energy, 11,500,000,000 kilowatt-hours would result—power equal to that from the burning of about 3,000,000,000 pounds of coal or 200,000,000 gallons of gasoline.

Until now, man's world has been an electron world. His available sources of energy have been associated with those tiny particles of matter spinning in their orbits in the atom. But now his world will be, at least in a sense, a nuclear world, with the boundless energy locked within the atom becoming available. We are faced with the greatest challenge of all time. Will we use this power to blast civilization from the earth, or will we learn to apply it usefully in a world where each of us is the next door neighbor to everyone else? Whether we are ready for it or not, a new age is dawning for mankind.—*L. W. Chubb,*

Director, Westinghouse Research Laboratories. "The World Within the Atom." '46. *p.* 27-30.

By the year 1939 it had become widely recognized among scientists of many nations that the release of energy by atomic fission was a possibility. The problems which remained to be solved before this possibility could be turned into practical achievement were, however, manifold and immense, and few scientists would at that time have ventured to predict that an atomic bomb could be ready for use by 1945. Nevertheless, the potentialities of the project were so great that His Majesty's Government thought it right that research should be carried on in spite of the many competing claims on our scientific manpower. At this stage the research was carried out mainly in our universities, principally, Oxford, Cambridge, London (Imperial College), Liverpool and Birmingham. At the time of the formation of the Coalition Government, responsibility for coordinating the work and pressing it forward lay in the Ministry of Aircraft Production, advised by a committee of leading scientists presided over by Sir George Thomson.

At the same time, under the general arrangements then in force for the pooling of scientific information, there was a full interchange of ideas between the scientists carrying out this work in the United Kingdom and those in the United States.

Such progress was made that by the summer of 1941 Sir George Thomson's Committee was able to report that, in their view, there was a reasonable chance that an atomic bomb could be produced before the end of the war. . . . I referred the matter on August 30, 1941, to the Chiefs of Staff committee . . . [who] recommended immediate action with the maximum priority. . . .

On October 11, 1941, President Roosevelt sent me a letter suggesting that any extended efforts on this important matter might usefully be coordinated or even jointly conducted. Accordingly all British and American efforts were joined and a number of British scientists concerned proceeded to the United States. Apart from these contacts, complete secrecy guarded all these activities and no single person was informed whose work was not indispensable to progress. . . .

Great Britain . was fully extended in war production and we could not afford such grave interference with the current munitions programs on which our warlike operations depended. Moreover, Great Britain was within easy range of German bombers, and the risk of raiders from the sea or air could not be ignored. The United States however, where parallel or similar progress had been made, was free from these dangers. The decision was therefore taken to build the full-scale production plants in America.

In the United States the erection of the immense plants was placed under the responsibility of Mr Stimson, United States Secretary of War, and the American Army administration, whose wonderful work and marvellous secrecy cannot be sufficiently admired. The main practical effort and virtually the whole of its prodigious cost now fell upon the United States authorities, who were assisted by a number of British scientists. The relationship of the of the British and American contributions was regulated by discussion between the late President Roosevelt and myself, and a Combined Policy Committee was set up. . . .

By God's mercy British and American science outpaced all German efforts. These were on a considerable scale, but far behind. The possession of these powers by the Germans at any time might have altered the result of the war, and profound anxiety was felt by those who were informed.

The whole burden of execution, including the setting-up of the plants and many technical processes connected therewith in the practical sphere, constitutes one of the greatest triumphs of American—or indeed human—genius of which there is record. Moreover, the decision to make these enormous expenditures upon a project which, however hopefully established by American and British research, remained nevertheless a heartshaking risk, stands to the everlasting honor of President Roosevelt and his advisers. . . .

This revelation of the secrets of nature, long mercifully withheld from man, should arouse the most solemn reflections in the mind and conscience of every human being capable of comprehension. We must indeed pray that these awful agencies will be made to conduce to peace among the nations, and that instead of

wreaking measureless havoc upon the entire globe, they may become a perennial fountain of world prosperity.—*Winston Churchill, former Prime Minister of Great Britain. Statement, August* 6, 1945. *Great Britain. Treasury. Statements Relating to the Atomic Bomb.* '45. *p.* 3-5.

Before the fall of France, French scientists working on the problem of atomic fission were sent by Professor Joliet to join the British scientists. Towards the end of 1942, the British proposed that an important section of the work should be carried on in Canada as a joint enterprise.

The primary material required for the production of materials for atomic bombs is uranium One of the world's two most important deposits of this substance was discovered by Gilbert LaBine near Great Bear Lake in Canada To preserve this important asset for the people of Canada and to protect the supply for the United Nations, the Dominion Government took over the ownership of the mines and the extraction plant.

A pile has been built in the Chalk River township situated on the south bank of the Ottawa river near Petawawa on a 10,000 acre site appropriated for the purpose. It will also produce large quantities of radioactive materials for application in medicine and research, and will provide a powerful source of neutron rays for research on atomic physics.

The construction of the plant followed an agreement in April 1944 of the Combined Policy Committee representing the United Kingdom, the United States and Canada. This Committee, under the chairmanship of Mr. Stimson, United States Secretary of War, and with Canada represented by Mr. Howe, was created as a result of a discussion between the partner governments at the Quebec Conference in 1943, to bring research work directed towards the atomic bomb in Great Britain and Canada into the closest cooperation with the tremendous undertaking in the United States. The Committee agreed that a pilot plant for the production of plutonium, a pile containing uranium metal and heavy water should be constructed in Canada, while the United States should concentrate on two other methods of producing fissile material, the production of plutonium in

the uranium-graphite pile, and the separation of U-235 from natural uranium.

The fundamental design of the plant has been the work of the Montreal Laboratory of the National Research Council. This laboratory was set up in Canada in 1942 for uranium research and staffed by a combined group of scientists from the United Kingdom and Canada, and included some from France assigned by the Free French authorities to collaborate with the British scientists. The Laboratory is administered by the National Research Council under its president, Dr. C. J. Mackenzie, and directed by Prof. J. D. Cockroft, Jacksonian Professor of Natural Philosophy, Cambridge University, England, with Dr. E. W. R. Steacie of Ottawa as Deputy Director. Its staff has now grown to over 400 and it has been described as the largest organization ever created in Canada to carry out a single research program.—*Bulletin of the Atomic Scientists. Mr.* 15, '46. *p.* 7.

SOCIAL AND OTHER IMPLICATIONS OF ATOMIC ENERGY

SOCIAL ADJUSTMENTS TO ATOMIC ENERGY [1]

A social scientist who contemplates the technical achievement involved in the release of atomic energy feels a deep respect for a professional achievement. I am not an authority on the history of science, but I doubt whether that long and amazing history contains anything that compares with the effective victory over the unknown that the scientists of atomic physics have won. Certainly, nothing could be as dramatic as the final culmination of that fifty years of work. Nothing that I may say later about social consequences of atomic bombs and atomic energy will gainsay for a minute the humble respect I feel for this successful attainment of scientific and technological objectives.

The history of inventions shows that at the time of a particular discovery the social effects to come from that invention can only be judged as the size of an iceberg is judged with seven-eighths of its whole below the surface of visibility. Natural scientists have as yet provided us very little of the essential concrete information on atomic energy; so a social scientist who comments on the social implications of atomic energy cannot speak about results but only about the process of social adjustment to the changes, present and prospective, set in motion by the release of that energy. To facilitate such a discussion, I state dogmatically a series of assumptions. They may be true, or they may be false. But they constitute the foundation for my remarks:

1. There is no foreseeable effective defense against atomic bombs.

2. No secrecy, nor cost, nor lack of materials will prevent bombs from being available to many countries within a few years.

[1] Joseph H. Willits, Director for the Social Sciences, Rockefeller Foundation. *American Philosophical Society. Proceedings.* 30, no. 1:48-52, January 1946.

3. The armament race in atomic bombs is already under way.

4. Atomic bombs may decrease the likelihood of war, but, if war starts, the eventual use of atomic weapons should be assumed.

5. The ultimate military position of the United States may have been weakened rather than strengthened by the discovery of atomic bombs

6. A world of atomic bombs puts a democratic regime at a disadvantage with a totalitarian one

7. There is no present practicable way of guaranteeing peace. However, the multitude of forces which make for peace can be strengthened.

8. Neither expectation of a sudden moral regeneration of mankind nor a magic formula for sudden world government offers as much hope for peace as patient working through established agencies, international and national.

9 Full support of U.N.O. is indicated.

10. No international machinery can be an effective substitute for a wisely oriented and skillfully manipulated foreign policy with other nations.

11. The penalties for stupid and malevolent action are enormously increased; and likewise the incentives for wise and virtuous conduct are more imperative.

12. Production, on a laboratory basis, of power from atomic fission is here; it would be wise to assume that its commercial development is only a matter of time and degree.

13. Attention should be focused, not exclusively on the social implications of atomic bombs, or of atomic energy, but on the entire accelerating advance of the physical and biological sciences and the technology which will produce even more titanic powers for man to use or abuse.

14. No social "atomic bomb" can be produced by social students to neutralize the atomic bomb or any other scientific weapon

This last assumption is true and the basic one on which to start discussion. No unitary, mechanistic answer on the social side is possible. It is strange how many intelligent people are wedded to the idea that problems which lie in the social behavior of

volitional human beings should respond to a mechanistic solution. The process of social adjustment, in a democratic society especially, ordinarily involves four steps:

1. Growth of a broad public awareness of the problem. On today's subject it is fair to say that our democracy is "rolling." If there is any general group today that is not discussing atomic bombs I have not heard of it. This "awareness" is a necessary pre-condition of wise action; but it alone does not guarantee wise action It can lead to foolish or malevolent consequences unless supplemented by the three other steps·

2. Scientific and scholarly analysis of the facts, processes and issues. This means, in the issues of atomic energy, a wide opportunity for collaboration between natural scientists and social scientists.

3. The development of competent experts—scientific and administrative.

4. Integration of the results of scientific studies and public sentiments and interests into wise public policies This isn't our national forte!

Given these preliminaries, I will comment on four areas where the social adjustments to atomic energy are critically important. There is a wide general awareness of the social issues in the first two: (1) international relations; (2) commercial power. The issues created in the other two have received much less attention. These are: (3) politics and government; (4) morals I am passing by two additional areas where the social implications undoubtedly exist, but where they as yet lie hidden—the impact of atomic knowledge on further scientific discovery and the use of atomic knowledge in medicine.

International Relations

The advance of science and technology—the atomic bomb is merely one episode in that advance—poses an old choice with a new and terrifying urgency. Modern society shall avoid war or war shall annihilate modern society. Atomic energy may enable man to destroy himself. The great hope is that man will perceive his danger and act while he still has the power to guard against catastrophe.

There is no way to guarantee peace. Even if a successful attempt were made to win world unification by conquest, such a world would not be peaceful, democratic, nor free. I see no hope of world government by formula. We have to work from where we are, not from where we wish we were. The slow building and strengthening of a world community that will settle its disputes without resort to war is a process that cannot be achieved by a simple tour de force. It requires the efforts of scholars and scientists, of experts and administrators, of statesmen and political leaders, of teachers, both popular and academic, each contributing in his appropriate way. But it is possible to go beyond such general assurance and, in international policy, to identify certain specific opportunities for emphasis which are of critical importance in efforts to build a constructive and durable peace.

The very imperfections of U.N.O. reflect the limits of the intellectual and moral climate of the world today. However, it is the available world medium through which to foster the habits and vested interests and acquaintances that make for an expanding role of international collaboration. Working through U.N.O. is the practical way to build towards a world political order that can forestall resort to the atomic bombs of war. It is also one of the media through which to rebuild the fabric of international economic relations which war has demolished twice in our time.

It is extremely difficult for a country, 90 per cent of whose minds and interests have been turned inward, to develop and maintain an effective foreign policy. This did not matter so long as our foreign policy consisted of high tariffs, unlimited immigration, the Monroe Doctrine, and the Open Door in China. But today it does matter, for the foreign policy of what we complacently call "the most powerful country of the world" vitally influences both the cause of world peace and our own national self-interest.

It is easy and natural and fashionable today to criticize the State Department. In the division of labor of our governmental organization the State Department has to be the leader of our team for peace, as the War and Navy Departments were the leaders of our team for war. The fact of this criticism, there-

fore, is a wholesome sign. But the task is the task of all of us. For example, competent work by scholars on international issues such as the integration of military and diplomatic policy, or in the field of foreign economic policy, may count towards the structure of international peace as surely as the work of any striped pants diplomat. There are two aspects of the work of the State Department which warrant mention. I do not see how it can be an effective instrument in the great responsibility which we carry until it achieves a greater degree of organizational continuity at the operating level than it now possesses. Perhaps (there will be many others who will know better than I) this is the point at which to begin the institution of a permanent undersecretary with a permanent staff of civil servants which remains unchanged even when changes in administration occur. Unlike the Labor Department, the Commerce Department, and the Agriculture Department, the State Department has no powerful group behind it concerned with its performance and protection. Perhaps there needs to be a "citizens pressure group" that will criticize, defend, and, nourish the State Department as an arm of government.

I have heard it said again and again in the last twenty-five years that this country brought able men to international conferences; that competent technicians had produced excellent specific memoranda; but that the over-all determination of policy was inadequate and often hastily improvised. If this criticism be true, it may reflect the size of this country, its intellectual immaturity on international issues, and a preference to finesse rather than face and choose policies. But all our preparatory education and intellectual work can be nullified if we do not take thoughtfully and competently this final organizational step of policy determination.

If world war is to come again in the next twenty-five years, it is more likely to come between Russia and her allies and the United States and her allies than between any other combination of powers. And such a tragic and futile war would prepare the world only for complete social and political bankruptcy.

I have no advice to offer to diplomats in the difficult issues which they face; but I do have a suggestion for scholars and

scientists. Russia has suggested, in her Academy of Science celebration, that science and scholarship may offer a foundation upon which the Soviet world and the Western world may meet. No one can say whether the channels of free inquiry in Russia will be open to objective Western students or not But, if they are, it would seem wise from the point of view both of knowledge and of the cause of peace to encourage academic and personal contacts between the competent scholars and scientists of both countries

I seem to have wandered far from the subject of atomic bombs; but atomic bombs dictate the elimination of wars, and the pursuit of that objective reaches widely into general as well as technical issues I return now to a problem which seems nearer to the subject of this conference—international inspection as a means of controlling the use of atomic bombs

I have been impressed with the complete faith expressed by some in international inspection as a means of controlling the manufacture and use of atomic bombs; then in turn by the complete lack of faith of others in its effectiveness and practicability. I do not know the answer, but this dilemma would seem to offer to natural scientists, engineers, industrial economists, and political students their opportunity to spell out the technical, political, and industrial issues involved in a system of inspection. Without the basis of such an analysis, policy cannot be wisely considered.

Commercial Atomic Power

Since it is possible, by human intervention, to slow down the rate of atomic fission, I assume it to be only a matter of time before atomic power will be available at costs that make it commercially practicable To go much beyond this statement on the basis of present information would be mere speculation. I view with some reserve the more enthusiastic predictions that the load of labor is to be lifted from the backs of men and that plenty will be enjoyed by all. The evidence for this optimism is not yet adequate.

Why speculate ahead of the evidence? Instead I call attention to the opportunity open for a collaborative study by physicists, engineers, industrial economists, and public administrators.

The object of this study would not be to guess about the social adjustments which commercial atomic power might produce, but to follow closely scientific and engineering developments and describe, as the facts permit, the social issues and adjustments which are likely to ensue. Usually the interpretation of such change comes after the event There is here an opportunity for natural scientists and social scientists, within certain limits, to predict social change and thereby to facilitate intelligent adjustment to it.

Politics and Government

The current tendency in discussions of social effects of atomic energy is to emphasize the dangers of war and the possibilities of commercial power. The political and moral implications of atomic power are usually ignored. But in the future these implications may be found to be at least as important

On the political side atomic energy looms as a giant new force propelling us towards the organization of society from the center. I give three examples: The May-Johnson Bill is one; and, although I share the concern which many scientists express over the bill, I suspect that any bill regulating atomic energy, which even the critics of the May-Johnson Bill might write, would contain many more restrictions on atomic physicists than have been traditional in scientific work For the second example, consider the same centralizing tendency which would probably operate in the field of atomic power. When atomic power is developed for commercial purposes, it will not be developed by private utilities, or even by municipally owned or state owned systems. The power will be developed in Federal central stations, and the system will be a Federal system. Although existing channels of distributing the power may be used, the policies for production and distribution will be increasingly Federal policies To the extent to which atomic power supplements other forms of power, the importance of central policies and central control will grow The third example is in the field of political rights If this country and Russia should go in for an armament race in atomic bombs, and the American people should come to realize that the Communist Party in this country

is not only a political arm of the Soviet Union but could be a potentially important military arm, one wonders how long our traditional guarantees of political freedom would be maintained

Such cases justify a query as to the impact, not only of atomic bombs and energy, but of all their born and unborn colleagues upon democratic political institutions. Moreover, what is the effect of such organizing of society from the center upon the status and independence of individuals; and, further upon the chances for peaceful international relations? How may the advantages of modern science and technology be reconciled with the conditions of effective political democracy and peaceful international relations?

The "Franklinian" minds capable of dealing with these questions, are not numerous but such minds can find issues worthy of their quality.

Morals

Finally, I can only mention the moral implications of atomic energy. What is the effect on man of this possession of the ultimate power of the atom? It has been interesting to me to notice that, at the various conferences on atomic energy which I have attended, controls at the international level were discussed, and controls at the national level also; but the controls of a moral and educational nature within the individual were not mentioned even when representatives of theological seminaries were present. The individual, seemingly, had become too small change to matter. John Lindberg, of the Economic and Financial Section of the League of Nations at Princeton, has stated the matter well in an unpublished manuscript written before Hiroshima. He puts it that the "outer kingdom" has outgrown the "inner kingdom" and a "social unbalance" results which will not be redressed until a basic equilibrium is restored. He traces the competition in our society of the "earthly city" (society) based on power and the "beloved city" based on love and sacrifice. The tragedy of the atomic bomb lies basically in the fact that, to survive in a world of such powers, we are compelled towards even greater emphasis and preoccupation with the means and the instrumentalities and the psychology of power. (It is significant to me that thoughtful

people in this country were more possessed by fear at the time of Hiroshima, when we were at the zenith of our power, than they were at Pearl Harbor when our defenses were down.)

There will be much declamation and exhortation about these social-moral implications of atomic energy and other scientific inventions. But, ahead of declamation and exhortation, we need honest clarification The minds which can really help society to understand the moral implications of modern scientific developments may be those of natural scientists (who are so deeply concerned with the product of their labors), or humanists, or men of affairs, or social scientists. To contribute helpfully these minds need (1) to be really capable of "the general view," (2) to understand the realities of the social world and the history of social ideas.

In conclusion, I return to my figure of the iceberg. It may be that further knowledge about atomic energy and further development of science and technology will point to problems of social adjustment quite different from those which I have stressed. But my guess is that, whatever the character of future scientific development, the main questions will continue to be questions of impact on war and peace, on power, on politics, and on morals. Whatever the course of developments, atomic bombs have made clear that the present is a time for greatness—a time for the abatement of pettiness of spirit—and a time for the pooling of disciplines.

I conclude with a quip which some wag used: "Atomic energy is here to stay but are we?

HOW ATOMIC BOMBS MAY BE USED IN THE FUTURE [2]

A single bomb, reported to have exploded at a height of 1000-1500 feet, totally demolished more than four square miles of Hiroshima. Structures as far as ten miles from the center of the blast were reported leveled. Sixty thousand persons were killed; one hundred fifty thousand more were casualties. A

[2] Atomic Scientists of Chicago *The Atomic Bomb· Facts and Implications*. p. 19-25.

second bomb, dropped a few days later at Nagasaki, was reported to be an "improved" model making the first bomb already obsolete. Even though the terrain was less favorable than at Hiroshima, the damage was more severe.

If no further improvements were to be made in the atomic bomb or in its mode of delivery, this would be the pattern of its use. A single bomber, or two or three, dispatched to a single target such as a medium-sized city (the United States has around 85) would eradicate it at a single blow. A country with a fleet of a thousand bombers, and an equal number of atomic bombs, could virtually annihilate an opponent in a single night's operation. Evidently, surprise in warfare—always an advantage—may now become decisive

Defenses might conceivably be set up so that no unidentified airplane could ever get within bombing range of a city Atomic explosives, however, may be used in war-heads of stratosphere rockets. Short range rockets such as the V-2 may be launched from ships or submarines at sea. Such long range rockets as the recently mentioned German "Vergeltungswaffe-4 (V-4)" were designed to reach the United States from Czechoslovakia, and the rockets discussed by our military men were reportedly designed to cross oceans and to strike within a given square mile None of these rockets can be warded off as can planes. In England, although radio proximity fuses were useful against planes and against the V-1 bomb, not a single V-2 rocket was prevented from reaching its target. No effective defense can be expected for the future

The extreme power and compact size of an atomic bomb make the use of either planes or rockets for their delivery unnecessary A compact "mine" or time bomb of atomic explosive, smuggled into the country, can be introduced into a city in some such simple fashion as in an automobile or light truck It can be disguised as a drum of fuel oil or hidden in a case marked *"Refrigerator"* Every public conveyance and means of public or private transportation thus becomes a possible agent of destruction. Or, the "makings" might be brought in piecemeal and assembled on the spot by an agent of an aggressor country. A soundless time mechanism or a radio-trigger tuned to a special

signal can operate the detonating mechanism at the desired instant. Such a mine need not be placed in any special strategic location; almost any place within a mile radius of the prime target is close enough. Inasmuch as neither U-235 nor Pu-239, the basic materials of the atomic bomb, emits any radiation permitting detection of its presence from a distance, detection of such time bombs becomes very difficult

With rockets and mines available, the next war, the atomic war, will probably start as a "pushbutton" affair. Rather than mobilize armies and airforces and declare formal hostilities, an aggressor will one night set off a flight of rockets and the light of morning will reveal only ruins where the cities of the victim once stood. A radio signal might accomplish the same result by detonating mines planted ahead of time. Under these circumstances the aggressor need not be a large country nor one with a large army Nor will the victim necessarily know the identity of the aggressor. Determination of the point of origin of stratosphere rockets is very difficult and atomic mines, being completely vaporized, leave no identifying pieces.

This extreme premium on surprise and the striking of the first blow may make even peaceful countries aggressors. In case of suspicion that another may strike, the only effective defensive measure may be to strike first. In any event, it is likely that possession of atomic armaments by many countries will not lead to peace.

Fear of retaliation by a country possessing bigger and more efficient bombs is an insufficient deterrent to aggression. First, one must recognize that the decision for or against war rests with small groups of men; and it is their momentary evaluation of the dangers to their position and to the welfare of their country that decides the issue There is no guarantee that the price of possible retaliation is one which they are unwilling to pay for the benefits they expect from administering the first effective blow Popular apprehension of the dangers of retaliation with atomic weapons cannot be relied on to guide the decisions of the heads of governments.

There are, moreover, many situations in which an apparent superiority in atomic weapons does not necessarily lead to a

greater efficiency in their employment for the purpose of retaliation. Since only a few hundred bombs are necessary to destroy the cities and a major portion of the industry of a country as large as the United States, in the event of an unchecked armaments race even small nations may become as effectively armed with atomic weapons as their larger neighbors. Once a nation has accumulated enough bombs to destroy the cities of its intended victim, more bombs are of no avail; nor will its victim find safety in the possession of an overwhelming number of bombs. For example, the nation intending aggression may rapidly evacuate the population from its own cities just before the unannounced attack. Thus, although a nation may suffer the loss of its cities through retaliation by a better-armed victim its casualties will likely be far fewer than those of the victim. A nation under duress may well decide in favor of a "victory" in this limited sense

Finally as mentioned above, the aggressor can well remain anonymous. The atomic mine and possible developments in long range missiles extend to the aggressor nation the hope that it will not suffer any retaliation. The aggressor's objectives may be satisfied without invading the enemy's territory and thus revealing its identity. Thus a commercial competitor may be eliminated by crippling its industries.

In the course of the history of warfare there have been several periods in which the balance of offense versus defense was upset, to the momentary advantage of those in possession of superior offensive weapons. During such periods crucial battles and even wars have been won on the basis of the temporary superiority of the attack. In time, however, each such lead was effectively reduced, if not eliminated, by the development of some innovation in defensive techniques. The preceding discussion does not imply that the destructive power of all conventional weapons has been allayed—the devastated cities of Europe are mute evidence of the lack of adequate defenses against massed bomber raids, for example. It implies only that a sort of equilibrium has been established between offense and defense, so that no single weapon could, unaided, sway the decision.

The development of the atomic bomb has greatly changed this traditional pattern of offense versus defense. Never has the offense become so entirely dominant. Never has there been a weapon whose first application in an attack will be almost certain not only to penetrate the defense, but also largely to demolish it. In this past war it was possible for the Allies to win even though they were on the defensive for the first two years. In a future atomic war the active defense will be enormously weakened after the first few minutes.

The enormously greater destructiveness of the atomic bomb over that of any previous weapon means that an adequate defense must be designed to prevent a *very large fraction*, if not all, of the atomic missiles from reaching even the *vicinity* of their targets It must be able to do this *at all times*, maintaining continuous vigilance in peace as in war, alert at a few seconds warning for efficient operation, and must be prepared for any surprise attacks or new attacking techniques.

The atomic bomb increased the destructiveness of explosives by several millionfold; some similarly fantastic improvement in the ability of the defense either to ward off the blow or to absorb its shock is now required. Romantic speculations on the miracles which science has wrought in the course of the last war are not a sound basis for evaluating the possibilities of such a defense. Not only does the present atomic bomb have an enormous lead over any existing defense, but progress is not likely to be confined to measures of defense. Much more destructive bombs in great numbers, delivered by a large variety of new carriers, are likely to offset any gains in defense.

Any defense must be based on: (1) reducing the number of missiles thrown; (2) interfering with their aim; (3) dispersing all possible targets for an attack; or (4) absorbing the shock of those which strike their targets.

The radically new principle employed in the atomic bomb has led to some speculation in the popular mind that a similarly original principle might be developed which could destroy the bomb or its basic material at a distance. In our present state of knowledge, hopes in this matter appear wholly imaginary; the atomic explosive is even freer from interference from a distance

than any ordinary explosive. Any active defense must be directed towards the bomb's carrier.

What may be called the positive defenses, consisting of aggressive action against the atomic bomb carriers, designed to prevent them from reaching their targets or to destroy them in process of delivery, must be as varied as the possible modes of delivery. To be satisfactory, a system of defense must be highly effective against conventional bombers, jet propelled planes, V-1 type buzz bombs, and V-2 type rockets, to account only for the types of carriers known at present The recent progress in speed of military aircraft, which tends to favor the attacker, makes it unlikely that a sufficiently large fraction of the attacking planes will be shot down far from their targets, even with the aid of radar, high speed fighter planes, and such devices as proximity fuses The same may be said of V-1 buzz bombs and of the newer, fast types of jet and rocket planes. In the past war a defense capable of shooting down 20 per cent of the bombers in an attacking force was considered excellent. With due consideration for the factor of surprise it is difficult to see how any measures of defense could be relied on to maintain the required very high efficiency. Atomic attacks are most likely to be unannounced blows struck during peace, perhaps by supposedly peaceful commercial planes on routine flights, or by pilotless rockets launched by ships or submarines near our shores.

Stratosphere rockets of the V-2 type, traveling at speeds of 3500 miles per hour (twice as fast as a high velocity shell), present a problem of a still different order Not one of those aimed at England was ever shot down The detection of an approaching long range rocket by radar is capable of giving no more than a few seconds or minutes warning, according to the radar experts Difficult as the detection of a rocket missile appears, it is an easy problem in comparison with its actual interception Conventional anti-aircraft weapons, such as fighter planes or shells, are much too slow. Only counter-rockets guided by radar show even remote promise. The system would have to be so complicated, and its operation would be contingent upon so many unknown and uncontrollable factors, that it is impossible to believe it could be 100 per cent effective, especially against possible saturation tactics employed by the enemy.

An effective system of defense for atomic bombs must also take account of various possibilities for secret delivery of the bombs in the form of preplanted mines. Since the bombs are small, they may be smuggled into the country disguised as freight shipments, or they may be carried in piecemeal via diplomatic pouch or by secret landings on our shores and then assembled and planted in our cities or other strategic locations by enemy agents Such mines can be set off by a variety of mechanisms, at a prearranged signal. They emit no radiations which might render them open to detection, and they may be hidden, even buried underground, and still be enormously destructive Mines can more certainly destroy their targets than can other methods of delivery such as planes. Their use attaches a high premium to efficiency in counter-espionage as a first line of defense. Even if it were possible to establish a rigorous system of inspection of all materials entering the country, and a periodic and thorough inspection of all our cities, it is hardly conceivable that such a set of protective measures can be made 100 per cent effective.

To date, the only proposal for a defense which, realistically, seems to offer any assurance whatever of diminishing the hazards of an atomic bomb attack upon this country is that which consists in rendering us a less attractive target for any adversary This country, because of its tremendous concentrations of population, industry, government and transportation facilities in a relatively small number of metropolitan centers, is one of the most vulnerable of all to atomic weapons, which are most efficiently employed against such concentrations. If we were to embark on a large scale effort to disperse the population, industry, government and transportation systems of all of our cities and industrial concentrations, to spread them out uniformly over the habitable area of the country, we could greatly minimize the effects of an attack upon us Further, we might place many important factories underground. To effect the same destruction, an enemy would then have to attack us with several thousand rather than several hundred bombs. It is obvious that such a program could only be carried out at the cost of industrial efficiency, and with the sacrifice of our standard of living, and of our free institutions and personal liberties. It has been estimated, for example, that the cost of dispersing our cities to towns of no more than 100,000

population would be about three hundred billion dollars. Moreover, it is probable that only temporary safety would be gained, for several nations have within their productive capacities the manufacture of even many thousands of atomic bombs, within perhaps as little as twenty years, and such a program of dispersal could not be accomplished in less than, say, ten years.

Thus it appears an inescapable conclusion that no combination of national defenses is capable of giving us any assurance of safety in the event of a large scale attack with atomic bombs. It is probable that a well prepared nation could save itself from subjugation, but not from the ravages of an overwhelming destruction. Thus we must revise our entire philosophy of defense. If we find that we must exist in a world in which nations can freely arm themselves with atomic bombs, we must organize ourselves to withstand a Pearl Harbor on a nationwide scale and still survive to prevent the occupation of our country.

MILITARY MENACE TO WESTERN CITIES [3]

The real point in issue here . . . is whether the atomic bomb will do a great and overwhelming amount of damage to American or European industrial cities since it has only been observed to do damage over rather lightly constructed cities, like the cities of Japan.

The nature of Major de Seversky's comment is that it will only do damage comparable to that of a very large TNT bomb carriable by one plane. Against this one has to look into the technical features of the situation. . . . It is true that we do not have any experience with the atomic bomb over a city of western construction. We have, however, some experience with large explosions in these cities. I think the most famous explosion was that in the harbor in the city of Halifax caused by the detonation of picric acid, which is similar to TNT, corresponding to 4,000 tons. That was out in the harbor some distance from the shore. It was outside the city of Halifax, and although I

[3] From statement of Dr. Philip Morrison, Atomic Physicist on the bomb project, before the Senate Special Committee on Atomic Energy, February 15, 1945. Hearings on S. Res. 179, part 5. p. 530-4. 79th Congress, 2nd session.

have only been in Halifax once, I would say that if you should pick out a city at random in the United States you would find a city similar to Halifax. It is not like lower Manhattan, but there is not much in the United States that is like lower Manhattan. This city was damaged pretty badly by this accidental explosion equivalent to 4,000 tons of TNT. I think the number of casualties is not well known, but it was estimated to be about 30,000. This is the best sort of experience we have in this direction.

In one German city there was a 5,000-ton explosion of ammonium nitrate, and there again the casualties—this was rather remote, out from the center of the city in a chemical plant—were only a few thousand. I think you have to think of these things to see that a 20,000-ton explosion, that of the atomic bomb, will do much the same sort of damage.

The scale factors in going from a 10-ton to a 20,000-ton bomb are known. It is not correct to say that there is 2,000 times as much damage. There is 2,000 times as much energy, but not 2,000 times as much area of damage.

However, one can look at some of the scale factors, and I think you will see the sort of thing we have in mind. For example, the standard British figures learned by experiment and also by actual observation in damaged regions show that for a 2-ton blockbuster. Let me give you a few figures. We have not, of course, exposed people to this, but from actual measurements made in the same way with the same instruments on 2-ton bombs and on the atomic bomb, and from actual observations of what 2-ton bombs do in European cities, we have some standards to go on. It is a question of measuring, not a question of opinion, as far as I can see. It is a technique one has studied and knows something about.

One distance, for example, is the distance at which lung damage from blast becomes important. This is surprisingly close to a bomb. That is, people are rather resistant to blast, so if a man is not hit by debris or pushed against a wall, or burned, but simply hit by a blast wave, it must be close to him. The figure given is something like 50 feet from a 2-ton blockbuster, and the man has a fair chance of surviving against this damage,

against lung damage That figure would go up to something like 1,200 feet for the atomic bomb.

In the same way, a 9-inch wall, which is a good example of grade B damage, would be expected to be pushed over most of the time at 200 feet from a 2-ton blockbuster, and I would say that the equivalent scale factor from our experience with this bomb would be about 4,000 feet.

Pressures due to a tornado produce only partial structural damage—a tornado would not have fazed the medical school or the Red Cross Hospital at Nagasaki. It would have done about the same thing the bomb did, smashed the insides. But the aerial photos would still look pretty good. That is what we call roof and ceiling damage—skylights, casements, interior partitions, and so forth.

The tornado scale of damage was produced 450 feet away from a 2-ton blockbuster, and about seven or eight thousand feet away from an atomic bomb, I would say.

Now, if you get 650 feet away from a 2-ton bomb, you have the effect of a wind gale as of a severe storm which will knock over billboards, light roofs, and probably knock over many Japanese houses, but not very serious. That same effect would be produced at about 14,000 feet as against 650 feet. All one has to do is to look at these scale factors, and it becomes hard to see how you can conclude that against any kind of target the two will not have qualitatively a different kind of damage—100 times as much—maybe 300, I wouldn't argue about that, and I think that is all that any responsible person has ever claimed.

It is perfectly true that the total area of damage in lower Manhattan would be much less than the total area of damage at Hiroshima; no one can doubt that I think the total casualty damage would be comparable, because the thing that protects Manhattan is that it is strong and densely populated. It was made to have a lot of people in it. I think in the same way, roughly, you would do about the same dollar damage in lower Manhattan as you do in Hiroshima. The building costs more to build and is stronger when you get it done

I don't think the military effect would be much less than the military effect of a bomb dropped at the right time of a day

over Hiroshima. If you dropped one at random on Manhattan, not Wall Street, you would produce an effect of much the same qualitative and quantitative damage as at Hiroshima. There would not be so much burning, but the buildings would still be broken down. There would be extensive class B damage, buildings made unusable, capable of repair' but not totally destroyed, extending over several miles You will have casualties running from 30,000 to 100,000.

If the hit were lucky, in the middle of the day while people were on the streets, it might be 200,000

I cannot see how a conceivably lucky hit with a 10-ton blockbuster could do anything like this. The whole point of what people have been saying about the atomic bomb is not that somehow it magically kills people. It does not vaporize them It does not make them into glass. It doesn't do any of these things No one who was responsible said that But it does produce extensive damage, damage which cannot be produced by less than 100 superbombers of a sort we don't have many of now. One has to remember also that to talk about raids of a hundred or a few hundred bombers measured against one atomic bomb does not give you the right factor. What one must think of in determining what this will do in the future conduct of war and solving the problems you have before you is not the question of what happens when one atomic bomb comes, but what happens when a thousand come, because we are told, and I can assert that it is true, that we can manufacture atomic bombs without appreciably increasing our plants. I think that to correspond with this sort of bomb production, Mr. de Seversky's figure as to the necessary airplanes—which I think he would find great difficulty getting off the ground—would be 200,000 bombers, with 2,000,000 trained crew and another 10,000,000 ground crew. I don't think you can load these people and send them off in a day or two days. . . .

SENATOR JOHNSON. Dr. Morrison, is it an exaggeration to say that one atomic bomb equals 20,000 tons of TNT?

DR. MORRISON. No, sir, that is a correct statement. . . . It is not a correct statement to say that it does the damage which 20,000 individual 1-ton bombs would do. That is no longer a

correct statement. . . . The basis of comparison is on energy released, and what we are saying is that the atomic bomb does the same damage that would occur if you had an arsenal containing 20,000 tons of TNT all in one piece, and simultaneously blew it up. Then you would have very comparable damage.

There are some additional factors, but for the purposes of argument they are not important; so I would say it is a sound statement to say it is like an explosion of 20,000 tons of TNT. It does not do as much military or tactical damage . . . as 20,000 individual planes each dropping 1 ton.

I might perhaps give a rough explanation of why this is. The point is that you blow up the center of this region very thoroughly. You blow it up into tiny, little pieces; whereas if you have 1-ton bombs, you blow up many more regions into medium-sized pieces. As far as the military effect goes, it doesn't matter if a man is blown into a thousand or five thousand pieces, or into two, as Colonel Warren reminds me. It is more efficient to kill a man by blowing him into two pieces than to waste your energy in tearing his building or him up into shreds. The building is useless and the man is dead.

All you have done is spread energy violently in this area. As you go farther out, the energy goes down. It is not true that 20,000 tons of TNT does 20,000 times the area damage as one blockbuster of one ton achieves, but it does do several hundred times as much area damage, and that is the point we are trying to make.

WITH ALL OUR LEARNING [4]

"We have nothing to fear but fear itself," said President Roosevelt a dozen years ago, and a few years later he gave freedom from fear a prominent place among the four freedoms. But that was before the death-dealing power of the atomic bomb had been demonstrated at Hiroshima. More recently Senator Thomas, in his book, *The Four Fears*, urged his fellow Americans to discard their fear of idealism, of entangling alliances,

[4] From article by M. C. Otto, Professor of Philosophy, University of Wisconsin. *Antioch Review*. 5: 463-79. December 1945.

of England and Russia, of revolution. He found these fears unhistorical as well as irrational, to be replaced by a courageous standing up to the problems, undoubtedly grave, which we have to solve. "I am not afraid to be an American," he said, "though I acknowledge the heavy obligations of our national position. Nor am I afraid to have all men enjoy the freedoms we enjoy here in America." But that, too, was before the horror over Hiroshima.

Hiroshima appears to have changed everything. In the words of Norman Cousins, it has suddenly intensified and magnified a primitive fear, "the fear of the unknown, the fear of forces man can neither channel nor comprehend." Overnight, according to him, this fear "has burst out of the subconscious and into the conscious, filling the mind with primordial apprehensions," so that "man stumbles fitfully into a new era of atomic energy for which he is as ill equipped to accept its potential blessings as he is to control its present dangers." The peril has assumed such monstrous proportions for a host of writers and speakers, that fear is being transfigured into a redemptive virtue. Each in his own style makes it a condition of human survival, as Mr Cousins does, that "the quintessence of destruction as potentially represented by modern science must be dramatized and kept in the forefront of public opinion . . . Only then will man realize that the first order of business is the question of continued existence. Only then will he be prepared to make the decisions necessary to assure that survival." . . . .

President Roosevelt was . . . right and Senator Thomas was right. The thing to resist, the thing to conquer is fear, and just now fear of atomic energy; not because there is no danger, but precisely because the danger is great. *We cannot afford to be afraid.* Let us suppose the danger is dramatized and brought to the forefront of public attention; it will not stay there. Fear can be aroused and spread abroad, and it can be exploited by those who know how to play upon the emotions, but it cannot be made to last. Men are not made that way. They won't take it. Perhaps they can't. At any rate they don't And if it could be, what are the chances that the right persons, the ones who do the greatest damage to the human cause, would be frightened

from their scheming? Those who are willing to risk disaster always gamble on escaping the consequences if disaster comes. History provides eloquent testimony to this ugly truth.

Moreover, fear while provocative is uncreative. That is the final word. It can push men into action, but to act wisely takes intelligence, the more so in times of great danger, and that kind of intelligence is not a product of fear It is the nature of fear to breed suspicion and distrust These attitudes in their turn give rise to behavior which intensifies the inciting fear. So on and on in a vicious circle that becomes more and more difficult to break through. Feelings, actions, ideas expressive of the fear, and only these, appear feasible under the circumstances. Anything else seems unrealistic, fantastic, even immoral At the same time the creative energies are paralyzed which, if freely brought into play, would lead to better understanding and co-operative effort. Consequently fear causes the situation to grow worse and worse, until the pressure of dread can be withstood no longer and violence breaks out.

It should be obvious that this analysis of fear psychology is intended to be applied universally; to hold, so far as it goes, not only of the American people, but of all peoples. They, too, cannot afford to be afraid, however frightful the outlook may appear. They, too, must resist giving way to fear, even if it is we, the United States of America, alone or allied with others, who try to make them afraid. And unless the relation of fear to the present crisis is seen in this worldwide perspective, there is no prospect that we shall deal intelligently with the gravity of the situation . .

What to do positively and constructively? It is safe to say that no one has the answer. Anyone who pretends to have thereby demonstrates that he has oversimplified the problem The thinking demanded is so revolutionary, and the acting with which it must be intimately combined is likewise so revolutionary, that if a few initial steps are suggested as a beginning, this is all that can reasonably be expected

Well, the disposition or temper of mind required of us should be unmistakable. It is *the deliberate acceptance of the crisis as an incitement to spiritual creativeness.* And the practical conduct

called for should likewise be evident Stating the objective for the moment in general terms, it is *conduct which puts spiritual creativeness to work in daily affairs*—in the small, everyday preoccupations which are fundamental to existence; in the broader interests that add excitement and color to living; and in those longer-range commitments through which the individual realizes his highest selfhood and, in union with others, enriches and glorifies the human endeavor.

The adjective spiritual may not be a happy choice. It is likely to offend the sophisticated sensibilities of the reader who cannot distinguish it from what Stuart Chase calls "high-power abstraction," and it will doubtless encourage false hopes in one who thinks of spiritual as essentially otherworldly. But it is still the best word available to designate certain life-elevating ideals. And it has the added value of suggesting continuity between ourselves and our forbears in allegiance to those ideals, a continuity to which we are indebted for much of whatever is praiseworthy in contemporary civilization, as well as for a good deal of our militant desire to improve upon traditional customs and institutions.

In any case, the problem is not one of finding the right word. It has to do with the conduct of life, and with life at its core and center.

Basically the task is educational, the reeducation of adults and the proper education of the young To some people this will seem a purely academic idea. Education takes time, they will say, and the need is urgent, immediate The magnitude of the peril is no greater than its menacing imminence Whatever is done has to be done in a hurry Unless we act quickly, the whole human business may be brought to a stop by an outbreak of super-atomic bombing. And who can deny categorically that they are right? There may not be time to get returns on an educational investment.

Nevertheless the solution lies ultimately in education. Whatever steps can be taken at once should of course be taken. But the radical change of individual and social motivation which is indispensable cannot be accomplished by an instant act, no matter how all-embracing. The life men live cannot be turned like

a flapjack in a pan. Realistic reform, the only reform that takes hold and functions, is reform embodied in new intellectual and moral habits, which is to say that it is the product of education. There may not be time for such reform, or it may turn out that man collectively does not have what it takes, but as Elmer Davis said in the face of an earlier crisis: "The world is run by people who did not slip back into passivity, no matter how disheartening their problem," by people "who sat down to think their way out," and then went at it "to work their way out."

Suppose it is tentatively agreed that the best approach is through education, where should the emphasis be put? In view of the situation in which we are it should be put on improving the understanding of science. As every one knows, scientific progress has been significantly instrumental in bringing about the present hazardous conditions. A clearer conception of science, of its aims, its experimental procedure, type of data and truth, range of applicability, and so on, will not in itself provide the way out, but it is a prerequisite to the inauguration of any plan of campaign, of any social program that will. And the deplorable fact is that this conception of science has not entered into the thought of the vast majority of people even in the most enlightened countries. A. J. Carlson is undoubtedly right:

> The modern man adjusts to an environment greatly modified by the scientific efforts of the few The "Peking Man," we may assume, adjusted himself as best he could to nature in the raw. A span of about a million years separates the two. And yet the two are about equally innocent of science, in the sense of the spirit and the method of science as part of their way of life. For science is more than inventions, more than gadgets, however useful and important they may be. Science is even more than the discovery of and correlation of new facts, new laws of nature. The greatest thing in science is the scientific method, controlled and rechecked observations and experiments, objectively recorded with absolute honesty and without fear or favor. Science in this sense has as yet scarcely touched the common man, or his leaders

Science in this sense has scarcely touched the common man or his leaders, but in another sense it has entered deeply and vitally and inextricably into the life of both. And because in the one sense it has not penetrated inwardly and in the other sense it

has done so more and more, mankind has come to the present pass. Applied science has showered men with a wealth of useful devices which are now so interwoven with desires and habits, so inseparable from the economic and social setup, that any other manner of living seems unthinkable. We insist on having more, not fewer, of the gifts of science, more conveniences, more labor-saving mechanisms, more time-saving speeds. And there is always the fascination of the scientific novelties themselves. Although the latest triumph of applied science may endanger the existence of civilized man, yet we look excitedly forward to the flood of atomic energy which is promised, we dream of new giants of power, we wait not too patiently for an unparalleled abundance of new tools and toys. Science the wonder worker has captured us body and soul, and there is no likelihood whatever that some unscientific utopia will ever tempt us away.

In one respect, then, we are science-hearted and science-minded, on whichever side of the tracks we live We lean on science as a lame man leans on his crutches. And where are we headed with the help of our scientific crutches? Surely that is a question of some importance. Science applied makes the going healthier, easier, more comfortable, but whither does it take us in the end?

It is here—namely, when we reflect upon life's direction—that science receives the cold shoulder. Possibly the majority of men and women are satisfied to allow the means and mechanisms of living to determine how they shall live, and all of us must do so more or less; but there are few people who never evaluate the worth of what they are doing, and for a considerable number the influence of critical evaluation pervades conduct as a whole. But while criticism of life, much or little, is thus nearly universal, there is an obvious lack of unanimity as to the criteria which valid criticism has to employ, and there is the widest possible disagreement regarding the source upon which any authentic appraisal of life must draw On one point there is conspicuous accord: science is not expected to throw light on problems of value A national poll would no doubt show that the *means* of living we gladly accept from men of science or their business representatives, but that the *ends* of living, especially the

so-called higher or finer ends, we insist upon getting from theologians, philosophic idealists, men of letters, artists, or from forays into the occult.

The cause of this twofold commitment is in the main historical. Some three hundred years ago a number of men of genius set out to acquire a new kind of knowledge which would enlarge man's control of his earthly destiny through mastering the forces of nature. For reasons which were good at the time, personal safety being one of them, they restricted the design of investigation to "facts" and ignored "values." As a result they handed down a cultural dualism which succeeding generations of investigators and thinkers have perpetuated and intensified; a dualism of objectives which not only separates the practical means of living from the higher ends of life, but makes them competing drives in the individual and in society.

Nowhere has this enterprise prospered more remarkably than in the United States. Drawing upon the physical resources of a vast, scantly-populated wilderness we have transformed it into a teeming commonwealth, and have advanced to a place of world leadership. It is a material leadership. We have the money, the machines, the natural resources, the industrial equipment and organization. In moral leadership—if what one reads can be trusted—we never stood so low in world esteem.

The atomic bomb has shocked us into a clearer appreciation of the fact that power alone is not enough. But the atomic bomb has done nothing to impair the notion that practical means and ideal ends belong to separate orders of reality, to each of which we owe allegiance in turn. We continue to believe—indeed it looks as if we were to believe it more than we have yet believed it—that to live and succeed a man must adopt materialistic standards, while to fulfill his latent possibilities as a civilized human being he has to commit himself to otherworldly standards. This is the fateful division which has to be healed, this division between "body" and "spirit," and between the institutions that have grown up to serve them in separation. Unless it is healed, every increase in power is potentially a step toward catastrophe.

A problem of these proportions should rule out all dogmatism. Too much of weal or woe depends upon success or failure

in its solution. At the same time it calls for the frankest and clearest declaration of convictions. Personally I am convinced as the foregoing discussion has implied, that the one hopeful approach is through the extension of scientific thinking to areas from which it has been all but excluded. By this is not meant the emptying of human life into test tubes, or the substitution of dial readings for the varied qualities of living experience. It means that the dependable, the objectively testable kind of thinking which is the rule in the natural sciences should be put to work in the great laboratory of man's search for the good life—the good life richly and profoundly conceived.

To sum up. The destiny of the American people, the destiny of mankind, hangs on what is done to symphonize these dynamic agencies of modern life—mechanized power and civilizing ideals. Historical events have separated them as self-contained, self-sufficient, self-justifying enterprises. They belong together in reciprocal relationship.

To bring such integration about will not be easy, for it involves interfering with vested interests and established customs. On the one side are the conscious or unconscious devotees of power: military leaders who contend that the first obligation is to make sure of supremacy in might; men of science who declare themselves undone unless their research ambition is unhampered by social responsibility; business executives who claim the right to turn atomic energy into cash. On the other side are the educators, men of letters, philosophers, prominent churchmen who, a hundred to one, argue that true values are intrinsically supersensuous. They are apprehended by means of pure reason, divine revelation, or mystical ecstasy, and when so apprehended will bridle the secular struggle for power.

No sensible person will expect to see the job finished in a year or a decade, but it can be begun at once by taking care of the pressing obligations which the contemporary upheaval has deposited on our commercial, political, educational, and religious doorsteps.

In the long run—to say it once more—the problem is educational. We need to be educated to want facts; facts about the world from which we stem, facts about ourselves as having our

origin in that world, facts about thinking and idealizing, and the conditions that cause these unique abilities to thrive or decline. It is about time, for instance, that we quit dodging the issue by concentrating our attention on abstractions—quit denouncing "war," bemoaning "human nature," belittling "politics," and really go after the conditions which have the evils we complain of as necessary consequences.

We need to be educated in reverence for the human quest, and in realistic idealism which is this reverence concretely applied.

We need to be educated in the neglected art of resolving otherwise irreducible conflicts, including war, man's direst enemy.

There is no ground for pessimism if we begin where we are and resolutely press on. There is no ground for anything else if we do not.

Can we read the sign in the sky over Hiroshima before it is too late? That remains to be seen. We have had the courage to stake everything on a race for power. Have we a comparable courage to make clear to our minds, and to espouse in day-to-day action, the full breadth of the way of life we have long professed? If we have, all may yet be well. If we have not, we are done for.

THE REAL PROBLEM IS IN THE HEARTS OF MEN [5]

Many persons have inquired concerning a recent message of mine that "a new type of thinking is essential if mankind is to survive and move to higher levels.

Often in evolutionary processes a species must adapt to new conditions in order to survive. Today the atomic bomb has altered profoundly the nature of the world as we knew it, and the human race consequently finds itself in a new habitat to which it must adapt its thinking.

In the light of new knowledge, a world authority and an eventual world state are not just *desirable* in the name of brother-

[5] By Albert Einstein, discoverer and exponent of relativity; *Chairman of Emergency Committee of Atomic Scientists, Princeton, N. J.*, in interview with Michael Amrine. *New York Times Magazine.* p. 7+. June 23, 1946.

hood, they are *necessary* for survival. In previous ages a nation's life and culture could be protected to some extent by the growth of armies in national competition Today we must abandon competition and secure cooperation. This must be the central fact in all our considerations of international affairs; otherwise we face certain disaster. Past thinking and methods did not prevent world wars. Future thinking *must* prevent wars.

Modern war, the bomb, and other discoveries or inventions, present us with revolutionary circumstances. Never before was it possible for one nation to make war on another without sending armies across the borders. Now with rockets and atomic bombs no center of population on the earth's surface is secure from surprise destruction in a single attack.

America has a temporary superiority in armament, but it is certain that we have no lasting secret. What nature tells one group of men, she will tell in time to any other group interested and patient enough in asking the questions. But our temporary superiority gives this nation the tremendous responsibility of leading mankind's effort to surmount the crisis.

Being an ingenious people, Americans find it hard to believe there is no foreseeable defense against atomic bombs. But this is a basic fact Scientists do not even know of any field which promises us any hope of adequate defense. The military-minded cling to old methods of thinking and one Army department has been surveying possibilities of going underground, and in wartime placing factories in places like Mammoth Cave. Others speak of dispersing our population centers into "linear" or "ribbon" cities.

Reasonable men with these new facts to consider refuse to contemplate a future in which our culture would attempt to survive in ribbons or in underground tombs. Neither is there reassurance in proposals to keep a hundred thousand men alert along the coasts scanning the sky with radar There is no radar defense against the V-2, and should a "defense" be developed after years of research, it is not humanly possible for any defense to be perfect. Should one rocket with atomic warhead strike Minneapolis, that city would look almost exactly like Nagasaki. Rifle bullets kill men, but atomic bombs kill cities.

A tank is a defense against a bullet but there is no defense in science against the weapon which can destroy civilization.

Our defense is not in armaments, nor in science, nor in going underground. Our defense is in law and order.

Henceforth, every nation's foreign policy must be judged at every point by one consideration: does it lead us to a world of law and order or does it lead us back toward anarchy and death? I do not believe that we can prepare for war and at the same time prepare for a world community. When humanity holds in its hand the weapon with which it can commit suicide, I believe that to put more power into the gun is to increase the probability of disaster.

Remembering that our main consideration is to avoid this disaster, let us briefly consider international relations in the world today, and start with America. The war which began with Germany using weapons of unprecedented frightfulness against women and children ended with the United States using a supreme weapon killing thousands at one blow.

Many persons in other countries now look on America with great suspicion, not only for the bomb but because they fear she will become imperialistic. Before the recent turn in our policy I was sometimes not quite free from such fears myself.

Others might not fear Americans if they knew us as we know one another, honest and sober and neighbors. But in other countries they know that a sober nation can become drunk with victory. If Germany had not won a victory in 1870, what tragedy for the human race might have been averted!

We are still making bombs and the bombs are making hate and suspicion. We are keeping secrets and secrets breed distrust. I do not say we should now turn the secret of the bomb loose in the world, but are we ardently seeking a world in which there will be no need for bombs or secrets, a world in which science and men will be free?

While we distrust Russia's secrecy and she distrusts ours we walk together to certain doom.

The basic principles of the Acheson-Lilienthal Report are scientifically sound and technically ingenious, but as Mr. Baruch wisely said, it is a problem not of physics but of ethics. There

has been too much emphasis on legalisms and procedure; it is easier to denature plutonium than it is to denature the evil spirit of man.

The United Nations is the only instrument we have to work with in our struggle to achieve something better. But we have used U.N. and U.N. form and procedure to outvote the Russians on some occasions when the Russians were right. Yes, I do not think it is possible for any nation to be right all the time or wrong all the time In all negotiations, whether over Spain, Argentina, Palestine, food or atomic energy, so long as we rely on procedure and keep the threat of military power, we are attempting to use old methods in a world which is changed forever.

No one gainsays that the United Nations Organization at times gives great evidence of eventually justifying the desperate hope that millions have in it. But time is not given to us in solving the problems science and war have brought. Powerful forces in the political world are moving swiftly toward crisis. When we look back to the end of the war it does not seem ten months— its seems ten years ago! Many leaders express well the need for world authority and an eventual world government, but actual planning and action to this end have been appallingly slow.

Private organizations anticipate the future, but government agencies seem to live in the past. In working away from nationalism toward a supranationalism, for example, it is obvious that the national spirit will survive longer in armies than anywhere else. This might be tempered in the United Nations military forces by mixing the various units together, but certainly not by keeping a Russian unit intact side by side with an intact American unit, with the usual interunit competition added to the national spirit of the soldiers in this world enforcement army. But if the military staffs of the U.N are working out concrete proposals along these lines, for a true internationally minded force, I have yet to read of it.

Similarly, we are plagued in the present world councils over the question of representation. It does not seem fair to some, for example, that each small Latin-American nation should have a vote while much larger nations are also limited to one vote.

On the other hand, representation on a population basis may seem unfair to the highly developed states, because surely great masses of ignorant, backward peoples should not carry as much voice in the complicated technology of our world as those with greater experience.

Fremont Rider in an excellent book *The Great Dilemma of World Organizations,* discusses the idea of representation on the basis of education and literacy—number of teachers, physicians, and so on. Backward nations looking forward to greater power in the councils of men would be told, "To get more votes you must *earn* them."

These and a hundred other questions concerning the desirable evolution of the world seem to be getting very little attention. Meanwhile, men high in government propose defense or war measures which would not only compel us to live in a universal atmosphere of fear, but would cost untold billions of dollars and ultimately destroy our American free way of life—even before a war.

To retain even a temporary total security in an age of total war, government will have to secure total control. Restrictive measures will be required by the necessities of the situation, not through the conspiracy of wilful men. Starting with the fantastic guardianship now imposed on innocent physics professors, outmoded thinkers will insidiously change men's lives more completely than did Hitler, for the forces behind them will be more compelling.

Before the raid on Hiroshima, leading physicists urged the War Department not to use the bomb against defenseless women and children. The war could have been won without it. The decision was made in consideration of possible future loss of American lives—and now we have to consider possible loss in future atomic bombings of *millions of lives.* The American decision may have been a fatal error, for men accustom themselves to thinking a weapon which was used once can be used again.

Had we shown other nations the test explosion at Alamogordo, New Mexico, we could have used it as an education for new ideas. It would have been an impressive and favorable moment to make considered proposals for world order to end war.

Our renunciation of this weapon as too terrible to use would have carried great weight in negotiations and made convincing our sincerity in asking other nations for a binding partnership to develop these newly unleashed powers for good.

The old type of thinking can raise a thousand objections of "realism" against this simplicity. But such thought ignores the *psychological* realities. All men fear atomic war. All men hope for benefits from these new powers. Between the realities of man's true desires and the realities of man's danger, what are the obsolete "realities" of protocol and military protection?

During the war many persons fell out of the habit of doing their own thinking, for many had to do simply what they were told to do. Today lack of interest would be a great error, for there is much the average man can do about this danger.

This nation held a great debate concerning the menace of the Axis, and again today we need a great chain reaction of awareness and communication. Current proposals should be discussed in the light of the basic facts, in every newspaper, in schools, churches, in town meetings, in private conversations, and neighbor to neighbor. Merely reading about the bomb promotes knowledge in the mind, but only talk between men promotes feeling in the heart.

Not even scientists completely understand atomic energy, for each man's knowledge is incomplete. Few men have ever seen the bomb. But all men if told a few facts can understand that this bomb and the danger of war is a very real thing, and not something far away. It directly concerns every person in the civilized world. We cannot leave it to generals, senators, and diplomats to work out a solution over a period of generations. Perhaps five years from now several nations will have made bombs and it will be too late to avoid disaster.

Ignoring the realities of faith, good will and honesty in seeking a solution, we place too much faith in legalisms, treaties, and mechanisms. We must begin through the U. N. Atomic Energy Commission to work for binding agreement, but America's decision will not be made over a table in the United Nations. Our representatives in New York, in Paris, or in Moscow depend ultimately on decisions made in the village square.

To the village square we must carry the facts of atomic energy. From there must come America's voice.

This belief of physicists promoted our formation of the Emergency Committee of Atomic Scientists, with headquarters at Princeton, N. J., to make possible a great national campaign for education on these issues, through the National Committee on Atomic Information. Detailed planning for world security will be easier when negotiators are assured of public understanding of our dilemmas.

Then our American proposals will be not merely documents about machinery, the dull, dry statements of a government to other governments, but the embodiment of a message to humanity from a nation of human beings.

Science has brought forth this danger, but the real problem is in the minds and hearts of men We will not change the hearts of other men by mechanisms, but by changing *our* hearts and speaking bravely.

We must be generous in giving to the world the knowledge we have of the forces of nature after establishing safeguards against abuse.

We must be not merely willing but actively eager to submit ourselves to binding authority necessary for world security.

We must realize we cannot simultaneously plan for war and peace.

When we are clear in heart and mind—only then shall we find courage to surmount the fear which haunts the world.

SCIENTIFIC SPIRIT IN INTERNATIONAL RELATIONS [6]

If we turn from the technical aspects of the bomb, to the scientific work upon which it rests, we discover vastly greater possibilities. The human powers, which have made possible the use of atomic energy, have more to contribute to international relations than this destructive forces of its first product. The scientific spirit, which has achieved such a magnificent triumph

[6] By Arnold Dresden, Professor of Mathematics, Swarthmore College. From paper presented to the Conference on Atomic Power and Public Policy, New York, November 1945.

in these steps toward the control of atomic energy, has qualities whose transplantation in the domain of international relations promises far-reaching results. It is through calling attention to these qualities, that the bomb may make its greatest contribution.

Let us then examine briefly some of the essential characteristics of the "scientific spirit." Be it remembered that we are not speaking of "scientific method," and that the characteristics which are to follow belong to "science" in its widest sense.

1. A basic element of the scientific spirit is cooperation, team work among workers in the same field. The time is long past when men held secret the results of their studies. Publication of results is now recognized as an essential feature in all scientific procedures At international scientific congresses, results of long patient investigations are subjected to the scrutiny of colleagues. Insulin, penicillin are suggestive words, around which could be grouped heartening instances of this cooperative quality in scientific research. The discovery and use of X-rays, of computing machines, of radioactivity, of wireless telegraphy, of aviation supply abundant illustrations of this aspect of the scientific spirit. One of the finest illustrations of this team work is perhaps furnished by the story of the researches in nuclear physics which made possible the atomic bomb itself. From the fundamental work of Einstein, through Hahn and Strassmann in Germany (1939), Bohn in Copenhagen, Curie and Joliot in France, Termi, Urey, C D Anderson and many others to Oppenheimer and his colleagues, there has been a steady forward march of the torchbearers—a procession in which humanity should take pride and whose high objectives must be guarded from the attempts at making them subservient to selfish aims. For, it is well to remember that it is the possibility of technical applications of scientific discovery and invention which often endangers the realization of their highest aims; the cooperative procedures frequently have to yield to restrictive regulations, to secrecy and to patenting limitations. Against these dangers, the scientific spirit has to defend itself.

2. The dominant objective of a scientific worker is the acquisition of understanding, of insight into the phenomena of the field of his interest. To reduce to intelligible order the iso-

lated facts that have been observed, to establish causal connections between them, to trace the historical development of the concepts and the methods which the human mind has created, these are the purposes which stir his ambition, which animate his hard work. It is these motives which bind together the chemist, the economist, the astronomer, the anthropologist Central to the scientific spirit is this restless desire to inquire into the material of human experience, not merely the flow of experience which it receives passively, but also the experiences which man sets up himself. I may be allowed to observe parenthetically that the acquisition of such insight requires the ability and, more important, the desire to recognize that relations have direction and that they can only be understood by considering them from the point of view of all the elements that are involved in them. The great nineteenth century German mathematician K. G. J. Jacobi, perhaps having in mind the wider applications as well as its special relevance to mathematical analysis, expressed a part of this idea in his dictum "Man muss immer umkehren."

3. The scientific inventor dying from hunger in his old age, is as common a picture as that of the Bohemian artist or the garret-inhabiting poet. Perhaps it is an equally fantastic distortion of a piece of reality. It is not a misrepresentation of the facts, however, to say that the scientific worker is ready to forego personal advantages of a material nature; that he may reap other rewards, those which come through a realization of hopes and ambitions—this is quite outside the point. There is no doubt that Newton, when concerned with differential calculus, Lavoisier with the process of oxidation, Faraday with the laws of electromagnetism, Herz with ether waves, Galvini with the electrical current, were not giving more than at most a fleeting thought to any personal advantages which might come to them as a result of their work. It is a truism that the pursuit of personal advantage is foreign to the scientific spirit.

4. The first step in a scientific investigation is to gather as completely as we can the facts which may bear on the problem in hand. An economist who wishes to inquire into the relation of the import trade in woolen goods to the cost of raw cotton, will begin by gathering all the information he can concerning

the amount and character of the imports of woolen goods over as long a period as possible and he will tabulate the prices which raw cotton fetched on the market, year by year. Perhaps he will find it useful to take into account also the amount of wool produced in this country and abroad He will not deliberately suppress facts which may conceivably have a bearing on his problem, if he wants to avoid being branded as a "fake scientist," a hireling of this or that special interest He may not succeed in discovering all the relevant connections, he may be in good faith in omitting some aspects which turn out later to be of importance, but he is thorough in his search for the facts on which his further study is to be based.

5. Finally, he presents the facts to himself and to his scientific audience without distortion, without "interpretation," in as far as this is humanly possible. The extent to which he succeeds in this may depend on circumstances partly beyond his control, upon his sources of information, upon the possibility of isolating the facts from the context in which they occur, upon the complexity of the "simple facts." He will try to let the facts speak for themselves.

We can perhaps summarize the characteristic attributes of the scientific spirit which have been mentioned, in the following key words: Team work, renunciation of personal gain, understanding, thoroughness in search for basic facts, honest presentation of facts. Falling in with the current fashion of mysterious initial compounds we obtain the cryptic symbol *Truth.*

Let us turn now to a very brief summary of the principles which appear to operate in international relations. Being strongly aware of my lack of competence in this field, I hope that the picture I am presenting is not too gross a caricature.

1. The most striking feature of this picture is the competitive spirit. Each nation tries to get the better of other nations. This competitive character may take very misleading forms. Protectorates, mandates, are too frequently euphemisms for methods of control; is a protectorate meant to shield the protected group or the protector? It is a rare occurrence when one party to an international conflict takes pains to understand the opponent's position as well as its own. There have been brave and

honest attempts at establishing international justice. Their ultimate failure rests perhaps on the fact that they had the weakness of exotic phenomena, that they were started in an unfriendly setting, that they were not indigenous to the international climate; they were reduced to starvation, because the environment did not nourish them.

2. The competitive spirit carries with it the pursuit by each nation of its own immediate national advantages without regard for the effect upon other nations. The protective tariffs and other obstacles to free trade are clear manifestation of this spirit. The economic problems of mankind, the problems relating to the production and distribution of the world's goods are looked upon by each nation from the point of view of its own interests, to the exclusion of that of other nations. But even a nationally unified policy is more than has actually been accomplished in all but a few nations. The most frequent state is that only a part of the national group is represented in a formulation of a nation's economic interest. Hence the conflicts between capital and labor, between the agricultural interests and the manufacturers.

3. Each nation considers every other nation as its natural opponent. Let me quote once more from Motley's *History of the United Netherlands*: "Surely, it was no epigram in those days, but the simplest statement of commonplace fact, that war was the nominal condition of Christians. Alas! will it be maintained that in the two and a half centuries which have since elapsed, the world has made much progress in a higher direction? Is there yet any appeal among the most civilized nations except to the logic of the largest battalions and the eloquence of the biggest guns?" And alas! we could continue, can we record much progress during the seventy-five years since Motley wrote? In spite of peace movements, in spite of pacts of Paris, in spite of courts of international justice on which so much hope was pinned, war is still the normal, the accepted way of carrying out a national policy; the expectation, at least the possibility of war, remains a permanent consideration in the conduct of international relations. To get the advantage of other nations, to steal a march on them, in the race for raw materials, for armaments, for strategic points, etc., is looked upon as the duty of every foreign office.

4. This carries with it that the facts about other nations are rarely allowed to speak for themselves. The foreign nation is "interpreted" at home, in the best case by ambassadors, in the worst case by spies. Consular servants are expected not only to assist their nationals in foreign countries, but also, to show the home nation how to use to its advantage the opportunities and peculiarities of the foreign nations in which they are stationed. The history of foreign countries is presented in each country as seen through the distorting medium of national ambition and glorification. It would be looked upon as quixotic if the consular services of different countries were to unite their tasks so as to secure the most effective production and distribution of goods, not for one nation, but for all mankind. It would probably be considered subversive if the school children in country A were to study the history of their country from books written by historians from countries B and C as well as from A, and the history of country B from books written by men from D. In describing the foreign policy of Spain in the sixteenth and seventeenth centuries, Motley writes: "To do unto your neighbor all possible harm, and to foster the greatness of Spain by sowing discord and maintaining civil war in all other countries, was the fundamental precept. To bribe and corrupt the servants of other potentates, to maintain a regular paid body of adherents in foreign lands, ever ready to engage in schemes of assassination, conspiracy, sedition and rebellion against the legitimate authority, to make mankind miserable, so far as it was in the power of human force or craft to produce wretchedness, were objects still faithfully pursued." Does this description have a familiar quality? Has foreign policy advanced very far, except in isolated bits here and there, beyond these objectives of the Spain of Philip II?

The war, the desire to liquidate this war and to end war, the participation of a large number of scientists in important tasks, have brought us to a state of active conflict between these principles of international relations and the scientific spirit, with which the world is now concerned. It is a conflict of basic principles; it should be clearly recognized as such From my point of view, the narrowly nationalistic methods have been placed in

a checkmate position from which the statesmen are desperately trying to extricate themselves. If the conflict were a game with fixed rules, the struggle would be over, the spirit of science should become the living spirit in international relations. But the rules of this conflict are not fixed, they are adjustable to the needs of those in power; and the power seems to be in the hands of the statesman. There lies the danger, and the responsibility of all those for whom scientific spirit means more than techniques and gadgets. They must recognize that the great accomplishments which the use of atomic energy makes possible imposes the obligation to deflect this energy from destructive to constructive purposes. They must resist the attempt to drag the scientific spirit down to the level of the competitive principles which control international relations, to make it subservient to nationalists aims. They must, on the contrary, free the relations between nations once for all from the control of narrowly conceived principles, and to extend to the realm of international relations the attributes of the scientific spirit. This is a difficult task and one might be pardoned for feeling that the struggle is lost.

There is, however, a last hope, and that is a strong one. For the ultimate power to change the rules rests not with the statesman but with the people. It is possible for the people to make the scientific spirit supreme in international relations, to let the principles of team work, renunciation of exclusively national gain, of understanding the other side, of thoroughness and of honesty in the presentation of facts, rule in the dealings between nations, to make the control of atomic energy a blessing to mankind instead of the cause of its extinction. Therefore let us resolve as follows: We, the people, demand that the scientific spirit become the ruling force in international relations.

MODERN MAN IS OBSOLETE [7]

However great our reluctance to acknowledge the birth of the new age, the fact is that it is already here. What remains to be

[7] By Norman Cousins, Editor, *Saturday Review of Literature*. From his book "Modern Man is Obsolete." p. 17-23. Viking Press. New York. 1945.

decided is whether we are going to stand up to it and meet it head on, or whether we are going to back into it; whether we should fulfill its responsibilities and develop its promise, or whether we should try to circumvent it on the theory that what we don't think about can't hurt us; whether we should carry on atomic research for practical use with the same urgency, the same fullness, the same scope and intensity as we have for destructive use, or whether we should restrict atomic research to purposes of war.

If these questions are decided affirmatively, then the long over-due mobilization of science for man's needs—principally health—can and should be promptly started. For the size of the opportunity is exceeded only by the size of the need. What a bitter commentary—not on science but on society itself—~~that~~ man has pierced the secret of atomic energy but is still baffled by the common cold! Who can tell what advances in medical knowledge might accrue to the welfare of mankind if society enabled its scientists and doctors to put as much mobilized effort into the study of man as there has been of matter! Cancer, heart disease, nephritis, arthritis, leukemia, encephalitis, poliomyletis, arteriosclerosis, aplastic anemia—all these are anomalies in the modern world; there is no reason why mobilized research should not be directed at their causes and cure Nor is there any reason why even old age should not be regarded as a disease to be attacked by science in the same intensive fashion.

Surveying other adjustments he will have to make if he chooses the positive course, man must consider himself in relation to his individual development. Leisure is a gift given him by technology; now he has the limitless opportunities that can come with time to think. The trend during the last fifty years toward shorter work weeks and shorter hours will not only be continued but sharply accelerated. No more than half of each week will be spent earning a living. But a revolution is needed in man's leisure-time activities—which so far have come to be associated almost entirely with the commodities of vended amusement. Once before, the world knew a Golden Age where the development of the individual—his mind and his body—was considered the first law of life. In Greece, it took the form of

the revolution of awareness, the emancipation of the intellect from the limitations of corroding ignorance and prejudice.

Once again, if man wills it, he can be in a position to restore that first law of life. But he will have to effect a radical transformation in his approach to and philosophy of education, which should prepare him not only for the business of work but for the business of living itself. The primary aim should be the development of a critical intelligence. The futile war now going on in education between specialization and general study must be stopped. There need no longer be any conflict between the two. The individual will need both—specialization for the requirements of research, general knowledge for the requirements of living. As for the problem of time in which to accomplish these dual objectives formalized education until the twenty-fifth or thirtieth year is doubtless indicated; but it should not abruptly end there. Education, like the capacity of the mind itself, has no rigid boundaries. Unlimited exploration should be the first imperative of any educational program.

One of the liabilities of modern education is that it has contributed to a dangerous compartmentalization both of knowledge and of progress. Dangerous, because what is needed today is an understanding of the interconnections and interrelationships within the entire province of organized knowledge. This understanding can help avoid a tragically compartmentalized approach to the building of a new world. Already, man is being offered unilateral solutions in terms of economics alone or politics alone or ideology alone or science alone or religion alone. But it is not Economic Man or Political Man or Ideological Man or Scientific Man or Religious Man by himself who holds the solution. Only the Whole Man is equipped to find and act on whatever solution may exist.

And the Whole Man requires whole education. This does not mean that he must become a specialist in every branch of the sciences and the arts, nor does it mean that specialization must give way to a superficial general study. What it does mean is that over and above specialized training there is a vast area to be cultivated in making a new science of integration—a science built on the interdependence of knowledge. It stands to reason

that if we are living in an interdependent world, we must educate for interdependent living.

We have saved for the last the most crucial aspects of this general survey relating to the first course: the transformation or adjustment from national man to world man. At present he is a world warrior; it is time for him to grow up and to become a world citizen. This is not vaporous idealism, but sheer driving necessity. It bears directly on the prospects of his own survival. He will have to recognize the flat truth that the greatest obsolescence of all in the Atomic Age is national sovereignty. Even back in the old-fashioned Rocket Age before August 6, 1945, strict national sovereignty was an anomalous hold-over from the tribal instinct in nations. If it was anomalous then, it is preposterous now.

It is preposterous because we have invested it with nonexistent powers. We assume that national sovereignty is still the same as it always was, that it still offers security and freedom of national decision. We assume it still means national independence, the right to get into war or stay out of it. We even debate the question of "surrendering" some of our sovereignty—as though there is still something to surrender. There is nothing left to surrender. There is only something to gain. A common world sovereignty.

At the heart of sovereignty throughout history there has been security based on the advantages of geography or military might. For sovereignty has been inseparable from power. But by the end of World War I, the validity of national sovereignty had sharply changed. The development of air power alone, apart from all other aspects of the world's inexorable trend toward close interrelationship, outdated traditional concepts of independence among nations. Yet we preferred to believe that there was no connection between a world being locked into a single piece and its over-all organization. Unfortunately, our unreadiness or unwillingness to see this connection did not cause the connection to disappear.

So much did this connection exist that it led to World War II. Despite six years of that new war, despite jet planes, rocket planes, despite the abrupt telescoping of a thousand years of

human history in the release of atomic energy, despite the loss of millions of lives, still active as though sovereignty can function as it did two thousand years ago.

Can it be that we do not realize that in an age of atomic energy and rocket planes the foundations of the old sovereignties have been shattered? That no longer is security to be found in armies and navies, however large and mighty? That no longer is there security based on size and size alone? That any nation, however, small, with atomic energy, is potentially as powerful as any other nation, however, large? That in an Atomic Age all nations are now directly accessible to each other—for better or worse? That in the erasure of man-made barriers and boundaries all the peoples of the world stand virtually unarmed in the presence of one another? That they are at the mercy of one another, and shall have to devise a common security or suffer a common cataclysm? That the only really effective influence between peoples is such influence as they are able to exert morally, politically, ideologically upon each other? That the use of disproportionate wealth and abundance of resources by any nation, when applied for bargaining purposes, do not constitute influence but the type of coercion against which severe reaction is inevitable?

All these questions have been in the making for centuries, but the triumph over the invisible and mighty atom has given them an exactness and an immediacy about which there can be no mistake. The need for world government was clear long before August 6, 1945, but Hiroshima and Nagasaki raised that need to such dimensions that it can no longer be ignored. And in the glare brighter than sunlight produced by the assault on the atom, we have all the light we need with which to examine this new world that has come into being with such clicking abruptness. Thus examined, the old sovereignties are seen for what they are—vestigial obstructions in the circulatory system of the world.

PLAN OR PERISH [8]

The will to use the chance before us is the pre-condition of discovering the secret. We have to make great decisions. We

[8] By Harold J. Laski, Chairman British Labor Party. Address, Nation Associates' forum, December 3, 1945. *Nation*. 161:650-2. December 15, 1945; *Same*. *Commercial and Financial Chronicle*. 62:2772-3. December 6, 1945.

have to make them on the understanding that the life and death of our civilization hang upon the wisdom of our choice; boundaries, frontiers, tariffs, the ignoble imagination which asssociates the greatness of a state with the neutral massiveness of its power —all these seem mean and petty issues upon which to dispute before the central issue is decided. Three men hurriedly improvising a formula in a room screened from the public view cannot be accepted by any of us as having the title to decide our fate. Not even a commission of eminent specialists acting under the authority of the United Nations Organization can have that title It is for the common people in every land to share in the shaping of their own destiny. If we proceed from any other premise than this, the victory is thrown away because the cause for which it has been fought is lost

What follows from this premise? First, there can be no secrecy; if the common people are to decide, the full materials for decision must be made known. Secondly, there must be no blackmail of the scientist into an enforced silence; those who seek to break the international community of scientists and men of learning prostitute knowledge to the service of power. Thirdly, in the exploration of this new realm of awe-inspiring possibility, the claim of private interest to own or control materials or processes would be to impose new chains of servitude upon mankind. Adam Smith's "simple system of natural liberty," now, as I gather, in special repute in the United States, is, in this realm, the direct road to serfdom. We know the evil and the pain which were the price of the first and minor industrial revolution. No one can be forgiven who permits its repetition on a far greater scale by making the second and major industrial revolution a means to a deeper division of society into the few who know all the gain of living and the many who know nothing but its toil. Let us say explicitly what needs to be said: every implication of this discovery means planned internationalism, economic, social, political. It is an international discovery. The planning of its application has been international. The organization of its future use must be international also.

There is no nation state fit to be trusted with the development of atomic energy. There is no private interest working for profit to whom its future could be safely confided. Were this new

realm to be controlled by generals or admirals, business men or professional administrators, it would become a kingdom of despair and not of hope. If anyone here tells me that the world is not ready for an international democratic government, there are at least two answers of final import. Who is responsible for that unreadiness if not the little, grasping plutocracy which has for so long made its private gain the chief end of human effort? From Amos and Hosea, through Rousseau and Jefferson, through Ruskin and Marx, through Morris and Tolstoy, that has been the single verdict of the prophet. Who is prepared to believe that this same little grasping plutocracy will undergo now a swift change of heart? The evidence is grimly unmistakable that it pays to mankind no other homage than the promises it makes in times of crisis, which it withdraws when the moment of danger is past.

I know of nothing so decisive as a judgment upon the men whose invisible empires have so largely shaped national policies as that we should stand in terror before a discovery whose peaceful development promises a future of abundance to mankind. We all think of it as a weapon of death. Already every nation prepares, through its government, to equip itself with the power to hurl death upon its fellow nations. No people seeks that power; it is governments that seek it. They seek it because we live under a system by which the many are exploited by the few, and war is the ultimate sanction of that exploitation. War is the outcome of the exercise by governments of unlimited sovereignty. Unlimited sovereignty is essential to the preservation of those legal relations which subdue all human behavior to their service. We shall get rid of war as we get rid of those legal relations and the evil power politics they involve. We shall not get rid of it on any other terms.

The League of Nations failed because there was lacking the will to make it work. The Kellogg Pact failed because, there too, that will was lacking. We have seen governments watch with indifference the destruction of freedom in country after country because they were unwilling to pay the price the social process exacts to preserve freedom. I am not proud of the British record in the evil years of appeasement; I have a deep sense of guilt

when I see the tragic spectacle of Spain. I do not think the ordinary citizen of Great Britain thought that the war was being fought to return, under any pretext, the Indonesian peoples to the sovereignty of Holland, or to organize the conditions upon which an evil social system shall be imposed in the name of law and order upon the peoples of Southeastern Europe—peoples who for the first time since the break-up of the Roman Empire see the faint dawn of hope. And let me add for myself that I accept as the acid test of the bona fides of the Labor government of Great Britain that it shall not merely declare its desire to see a free and self-governing India, but shall organize the conditions necessary to the fulfilment of its desire without the wish to delay an outcome so clearly inevitable.

If we want freedom, we must have peace. If we are to have peace, it is not enough to will its advent on the formal plane of empty desire. We must organize the conditions which make it to the interest of nation states to put war outside the frame of reference within which human impulses operate. That means that sovereignty must go; that means, also, that the interests which sovereignty protects must be recognized as outmoded in character and dangerous in operation. Just as the feudal system had to go, so the system by which the business man has made the commonwealth an unhappy dependency of the market economy has outlived its usefulness. It is clear to any honest observer that a society dominated by business men could not be trusted to create the mental climate in which the development of atomic energy would be confined within the framework of peace. They would not give the common people education because they fear its outcome. It is the business men who have split our society into two, the political society and the economic society. They have made the policeman the sanction of the first and the threat of starvation the sanction of the second. There is only one country in the world today where this dichotomy has been transcended. There is only one country, also, where science and technology can be developed without sacrificing the education of man and risking the breakdown of social well-being or community consciousness. It is significant that only in the new world of Russia has the business man ceased to count. It is also significant that

one of the major preoccupations of the great vested interests is now to keep the "secret"—which is no secret—from the knowledge of Russia. You know the result—a halt to confidence and the rise of ugly suspicion about a third world war

The first condition of peace is to subordinate a market economy to the claims of peace. It would be a bold step to take; the alternative is to permit the business man to fix the criteria by which the future of atomic discovery is determined. To do that in an age of political democracy is to force the contradiction between a society depending upon the elevation of human dignity and a society depending upon human peonage to develop to the point of conflict. The one searches for new standards of behavior, for a new education, and therefore for an ethics of life and not an ethics of death. The other needs that "beneficent private war," the law of the economic jungle, which is afraid of the democratization of knowledge, anxious for an ethics of death, eager to make leisure cheap and trivial instead of full and creative. It is not accident that our schools and colleges, our universities and foundations, even the churches, are the instruments of big business. It is not accident that the press is now a branch of big business too. It would be madness to let the purposes or the methods of private enterprise set the habits of the age of atomic energy. For those habits would then, like the habits imposed by the men who after 1789 made this world, become the habits of the new world.

We have come to the boundaries of the final dividing line between liberalism and socialism. We are choosing between institutions which assume that freedoms must be won by the few and institutions which assume that they must be planned by the many. Either we must have power in the hands of men who use scarcity as the means of compulsion, or we must give it to men who find abundance is the instrument of freedom. There is no middle way Free enterprise and the market economy mean war; socialism and planned economy mean peace. We must plan our civilization or we must perish.

I accept the need for the United Nations Organization in the first instance to begin the task before us. But I accept it on conditions. No secrecy; no invasion of the internationalism and

the public integrity which are the glory of science and learning; no subordination of the scientist to that "practical man" who thinks it is wisdom to have habit without philosophy. Let the new institution for intellectual advance be given the chance forthwith to show that Plato was right when he said that the Minister of Education must be more important than the Minister of War. Let us show by a New Deal on a scale far wider and far more profound even than Franklin Roosevelt's New Deal that poverty is a curse of man's making even though he had the insolence to affirm its necessity by making it the outcome of God's plan for the universe. We in Britain have no more right to be content with the slum house and the slum mind than you in the United States have the right to evade the fact that you have acquiesced for eighty years in degrading twelve million Negroes by force and fraud and fear. This is not the time to rest content with a temporary plaster upon such deep and open wounds. This is the time to begin a new civilization, based on the freedom which comes when men have a map of the complex universe in which we live, have the assurance of security, and are no longer driven to work by the fear of starvation. Today we are in prisons where we have the key to freedom. When are we going to open the doors?

Do not believe for one moment that I think our task an easy one. But let us honestly face what the task is. We are societies haunted by fear and insecurity because we have made death the sanction of life and left its operation as a sanction to men who exploited its terrors to keep the many poor and ignorant and deceived. Now we know that we have reached the point where if they continue in power their demands will impose the law of the jungle upon us all; they sit there, believe me, in the dark at Nuremberg, when we indict men of their kind, we indict the same types in every society where democracy is not the participation in the processes of government by free citizens who live by the sanction of life because they have recognized necessary limitations and are thus free from fear. Nazism in all its forms is the culmination of a society built upon the anarchy of free enterprise; when it subjects man to the economy of the market, it destroys his right to be man. That is why we must alter the

central principle of our civilization to planned production for community consumption. From that central principle alone flow the ethical values which can renovate and refresh this dying civilization. Without it we shall have done no more than make a supreme discovery in the art of social destruction. With it we can make a supreme application of a new power to the art of social creation.

We are before a revolution more mighty even than the vast change which came with the reorientation of men's minds effected by the scientific discoveries of Copernicus and Kepler. These required a new society and a new culture. They were obtained, but they were obtained by the degradation of the mass of mankind. Now we too require a new society and a new culture, this time a democratic culture in a free society. That prospect arouses fear and distrust in that middle class whose triumph was slowly achieved in the three hundred years after 1600. Now they want to arrest the dynamic of history at the point where their triumph is crumbling into decay. They cannot succeed and they ought not to succeed Their day is over. Their thought is bankrupt, their ethical values are obsolete, their dogma is an angry anachronism. A new social philosophy is necessary for a new world Let us admit it can be born only of a new social order.

Do you ask why? In the deep tempest of the Civil War Lincoln gave the answer. "The dogmas of the quiet past are inadequate to the stormy present. The occasion is piled high with difficulty, and we must rise with the occasion. As our case is new, so we must think anew and act anew. We must disenthrall ourselves." *We must disenthrall ourselves;* I venture to repeat those words In no other fashion can we face this challenge with the proud confidence of free men.

EXCERPTS

There is another facet of the world situation which this scientific and technical development has brought to the forefront, namely, the immense responsibility now placed in the hands of those with exact knowledge of the steps necessary to release.

atomic energy. It has been stated that adequate measures have been taken to secure patents on all vital processes, and all rights in such patents have been assigned to the governments concerned. At present, this must mean that the United Nations, and especially Great Britain, the United States and Canada, hold in their hands a weapon with which they can dominate the world—a responsibility the discharge of which will require the highest degree of statesmanship. They also hold a potential source of power capable of contributing immensely to the welfare and material progress of mankind—a further and even greater responsibility. How will they use it? Governments are notoriously impersonal, and they come and go. It therefore devolves upon the individual, be he man of science or layman, to understand the potentialities of atomic energy, even if he comprehends little of the method of its release; and to insure that his elected representatives, from whom his government is chosen, are also aware of their responsibilities in the matter. It is not a matter of exact knowledge so much as an appreciation of right and wrong in dealing with our neighbors, who are now every nation of the world; indeed, the alternatives would seem to be an international brotherhood of nations or chaos. There can be no question of halting investigations until mankind is fitter to receive them; if material research has outstripped the progress of knowledge of man, then the tempo of investigation of man as a social being must be increased until both can progress, side by side, carrying man onwards to the higher ideals of life for which the best of each generation are always striving.—*"Atomic Energy: an International Responsibility." Nature. Ag.* 11, '45. *p.* 154. *Macmillan & Co. London.*

World cooperation depends in the long run on the information, ideas and attitudes of *individual* men everywhere. The United States should invite other nations to join with it in a crusade of education, domestic and international, and on all levels—through schools, colleges, churches, adult education, and publicity channels. The purpose of this crusade should be to promote mutual understanding and friendship among peoples, to persuade men that despite differences of belief and

institutions they can be united through awareness of common frailties and aspirations; to insist that discipline of the emotions in the exercise of moral choice is an inescapable human responsibility; and to demonstrate that in an atomic age the making of a cooperative and peaceful world is not merely moral idealism. it is practical politics and essential for survival. . . .

The atomic bomb has shattered more than things physical. Its impact reverberates not only in science but in politics and economics and morals. It has compelled the scientist to plead loudest for the benison of religion and the guidance of the social sciences, and summoned the philosopher to meet an issue where abstraction will not suffice. The bomb has exploded any illusion that one department of knowledge can safely be cultivated in isolation, and thrown into startling relief the failure of man's moral conscience and social intelligence to keep pace with the giant stride of his science and technology.—*Colgate University. "Atomic Energy: the Alternatives Before Us; Recommendations Adopted by the Faculty."* '45. *p.* [3].

The atomic bomb is a thousand years ahead of the San Francisco Charter. If it forces mere stalemate between the nations, if it only freezes, in a numb and fearful truce, the aggregations of power, this terrible, wonderful new strength will finally break all that it builds, all that has been built, all that could be used for building. It is gift or curse, according to the use it finds Gift, if the stuff imprisoned in the bomb is liberated for the service of humanity. Gift, if it helps all the peoples to full creative living. Then surely, it is the final, valid currency of peace. But if it buys no more than an armistice between push buttons, it is the curse of Cain, and we have come this far only to dance in flames.

The atomic bomb calls for a new charter, for a new conference. For decisions reached audaciously to match the audacity of the bomb itself It makes a fresh demand for courage, and an end of compromise and cowardice.

The alternative to Chaos is grander than all dreams, and we are greater than our dreams.

We, the living, are the ancestors of a people who will be, truly, men like Gods. We will not fail them.

Among all creatures the human has the marvelous bent for the art of survival. The universe is none too big for him.

Man is no puny thing He is greater than all his tools. He burned himself with the first fire, but there came a day when he built a forge, and made a plow.

Today man turns the key in the last padlock of power. Tomorrow he will be worthy of his freedom.—*Orson Welles, Actor, Radio and Theatrical Producer. In 1938 Mr. Welles gave his famous Martian invasion broadcast, an adaptation of H. G. Wells "The War and the Worlds." Free World. S. '45. p.* 28-9.

No one is to be trusted with power. That is the lesson. The only possible alternative to the self-annihilation of civilization is the transformation of civilization into a pattern of relationships in which no man can rule another, but all are ruled by all. The sovereignty of the people can alone protect the people. We call it democracy, but we have not learned its ways. It was once an ideal. It is now a necessity. There is no alternative.

I am not speaking of a national form of government. I am speaking of the basic structure of human relations—planetary relations. Nothing but allegiance to the cause of all mankind by all mankind can save us now But this is not primarily a political problem It is primarily an educational problem. . . .

We have dreamed of man freed from bondage to man. We have dreamed of man freed from bondage to those ways that have hemmed in his mind and hampered the full use of his powers. We have dreamed of man awakened to the vision of a commonwealth of humanity and disciplined to loyalty to the good of all If we could only awake from this dream and see the abyss before our feet we could use our knowledge to make the dream come true. This is all there is to set against the bomb: another dream, to be realized by a devotion which will match the devotion of the scientist and the fanaticism of the

nationalist or the ecclesiastic.—*Hugh Hartshorne, Research Associate in Religion, Yale University. "Prometheus Unbound." Religious Education. Ja.-F. '46. p. 5.*

One of the most important contradictions to be recognized in the new technic of atomic energy is revealed when it is examined as a resource. Atomic energy as a resource includes not only the mineral resources and the stockpiles of strategic materials that are or may become essential to the technic, not only the industrial plant and equipment already constructed and representing an investment of public funds, but also *the unpredictable achievements of future research still to be organized* along the whole frontier of the periodic array of the chemical elements. The material, industrial, and further-basic-research aspects of this resource present a particularly difficult problem to politicians with their largely irrelevant credentials for filling offices of public responsibility in this science-centered culture-in-crisis. They do not as yet understand how to achieve the necessary measure of social control over the new technic without fatally shackling the most significant component in the technic, the basic research still to be organized and released.

How the resource character of research was recognized by the one-time National Resources Committee can be learned from an examination of the following excerpts from their preliminary report to the President:

> Research is a national resource which can not be measured in terms of money or amount. The quality of research, the facilities for it, the atmosphere in which it is undertaken, and the supply of research workers must be conserved and developed like other resources. Upon the experience and facts developed by research, we base our planning and our policies in government, industry, business, education, and in our personal lives.
>
> Research is one of the nation's very greatest resources.

Sharing this conviction, President Roosevelt wrote to Vannevar Bush, Director of the Office of Scientific Research and Development, established as a war agency, a letter which said, in part:

> The office of Scientific Research and Development . . . represents a unique experiment of teamwork and cooperation and coordinating sci-

entific research and in applying existing scientific knowledge to the solution of technical problems paramount in war. . . .

There is, however, no reason why the lessons to be found in this experiment can not be profitably employed in times of peace . . . for the improvement of the national health, the creation of new enterprises bringing new jobs, and the betterment of the national standard of living.

—*Social Control of Atomic Energy, by Oliver S. Loud, Department of Physical Sciences, Antioch College. Antioch Review. D. '45. p.* 315-16.

Recently the proposal has been made that the scientists themselves come together from all lands to form a world association of physicists who will agree among themselves, as scientists, with a full awareness of their unique position, to keep the peace by refusing to lend their knowledge to the making of atomic bombs.

If the scientists who, by profession and tradition, are dedicated to disinterested, impersonal research, and who have long accepted the internationality of science, will accept this professional responsibility, then we can begin to arraign all the others who are irresponsible in their several fields—the political leaders and legislators, newspaper owners and columnists, and commentators; the international manipulators of economic affairs, the cartelists; indeed, all those who are now privileged, as individuals and in groups, to provoke and to contrive war and otherwise to disturb peace.

No nation, as Edmund Burke told us, can be indicted, but we can and must fix responsibility upon the individuals who, in positions of power and authority—military, naval, economic, and financial (and now scientific)—are the active principals and directors of the national, monolithic, aggressive state. If there is to be atomic warfare, it will come by the plans and decisions of specific individuals who have deliberately calculated their preparation and use upon specific targets. If we will accept the principle of accountability, these can be identified and legally tried and convicted for their individual and joint acts, just as the leaders of a mob can be tried and convicted for arousing and directing mob action. A firm declaration of this policy and application of this rule may offer what the many paper

schemes of control and inspection are vainly seeking to achieve for controlling atomic bombs

Curbing these irresponsibles is not a revolutionary act. It is the continuation of our legal traditions which, over the centuries, have recognized the principle of accountability for actions injurious to others. Just as in the early days of Anglo-Saxon jurisprudence the principle of individual accountability had to be wrought out and then painfully established, to replace the ancient doctrine of group responsibility, so today we face an equally momentous step, of fixing responsibility upon individuals for the disturbance of peace and world order Today we can now assert and prove that these specific individuals, *with intent,* plotted and planned the war in which they used their nation and its sovereignty for deliberate aggression

If we can make this clear, perhaps we can enlist the men and women of good will the world over in supporting this first concrete action for establishing the responsible conduct necessary for world order, the indispensable condition for the effective operation of the United Nations Organization or any world state.—*Lawrence K. Frank, Chairman, Committee on Science and Society, American Association for the Advancement of Science, Director, Caroline Zachry Institute of Human Development. Science. Mr.* 22, '46. *p.* 350-1.

So far I have considered this bomb from the point of view of maximum danger—the total ruin of the high civilization which we have inherited from our ancestors and which we have defended at terrible cost in two recent wars. Assuming that we avoid bringing such a catastrophe on ourselves, there are other problems upon which it would be wise for us to reflect. There is, for example, the bearing of this invention upon the future of political liberty as we understand it: liberty to criticize authority, to choose our avocations and mode of livelihood, to change our laws and institutions. Whether it remains for years to come only a potential source of destruction or whether it can be turned to peaceful ends, this new source of energy must remain under state control and therefore must increase enormously the power of the state over the citizen. Hitherto, a

great increase in state power has rarely made for liberty of any kind. This fact is perhaps blurred today. For large masses of the population much of the content of political liberty in the past has been theoretical only, since in fact they have been under economic constraints and fears which have prevented the enjoyment of freedom in a large sense. Hence for the average man today an increase of state power has actually meant an increase in liberty and has brought with it a sense of emancipation. If past history (which the average man does not know) is of any guidance, this *interim* stage is unlikely to last very long. It therefore becomes of first importance to us to avoid the line of development which has been followed so often in human societies where the tendency has been to return from contract back to status after advancing from status to contract. This question is of greater significance now because every new instrument of force under state control lessens the chances of successful revolution—the last safeguard against perpetual tyranny. The invention of railways, allowing a rapid concentration of troops, even more than the building of wide roads broke the localized power of the Paris mob in the nineteenth century. In the twentieth century the machine-gun, the armored car, the aeroplane, and the tank in the control of authority have destroyed the possibility of any revolution which is not 100 per cent totalitarian (and therefore unlikely to favor liberty) or does not, as recently in Spain, develop into a fearful civil war. Even so the success of the Spanish revolution, and for that matter of the three major revolutions of our time, in Russia, Italy, and Germany, was due to special circumstances unlikely to recur. We might do well to think over this matter and to ask ourselves what domestic safeguards, if any, may be available to us against the misuse of this tremendous concentration of power henceforth in the hands of the state.—*E. L. Woodward, Montague Burton Professor of International Relations in the University of Oxford. "Some Political Consequences of the Atomic Bomb." Oxford University Press. New York and London. '46. p. 27-9.*

Today when the malevolent possibilities of the atomic bomb have been made clear as a bell to hundreds of millions all over

the world, nations of good will are in a position to close ranks once more. To be successful in any large way we must have just as clear an objective as we had before. It lies ready to hand in an energetic and world-wide attack on poverty—poverty symbolized at first by the need for food, clothing and shelter, but ultimately recognized as a blight gnawing at the mind and soul and unity of mankind. Under modern conditions of rising educational standards and a close-binding system of communications there can be no perpetuity in a civilization part prosperous and part degraded beyond belief.

We act in scientific management on the assumption that a factory which is say 50 per cent efficient throughout its several departments rests on a better organizational basis than one where some of the units rate only 25 per cent and others 75 per cent. So in our reorganization work looking toward improving the over-all well-being of an industrial plant, we seek to improve first those units having the lowest rating In looking over the map of the world the areas are fairly well known where human suffering due to poverty is at a maximum. But the techniques for poverty abatement are not known—have hardly been studied with human welfare as the dominant incentive. If just a few nations would throw together in a common pool a group of colonial "possessions" or parts thereof, not necessarily permanently, and then announce the appointment of a general staff to work toward the improvement of the standard of living and the ultimate abatement of poverty in those areas, a great thrill would sweep the world—such a thrill as would drown out the fears of mankind born of the atomic bomb. Given the right conditions, certain areas in Latin America might be included.

One does not have to go into the detail of the composition of such a general staff. Nutritionists, engineers, economists, soil and water conservationists and businessmen would be included. The only qualification after demonstrated experience and competence would be a conviction on the part of the appointees that there was a job to be done and one that could be done. Obviously, the general staff would have to be given a fairly free hand. The operational expenses connected with such a scheme would be relatively small. Such capital outlays as may be found

desirable would be forthcoming through the agencies already provided for in the Bretton Woods and United Nations Organization agreements. Perhaps a demonstration made in this area, and under great difficulties recognized in advance, might afford an illustration of what government by experts untrammeled by the seamy side of politics and diplomacy might mean in the life of man on this earth The philosophy and practices inherent in this type of human reclamation work carried on in the islands of the Pacific, over vast areas in Africa and the Far East, might easily so commend themselves to our own people as to sound the doom of peonage, share-cropping and industrial slums here at home.

I would gladly refrain in this connection from mentioning any special interest but the pillars in the house of free enterprise should be reminded that, insofar as the standards of living among backward peoples can be raised, it means more business for those "at home," whether this be Great Britain, Russia, France, U.S.A. or any other industrialized nation—*Morris L. Cooke, Consulting Engineer. Address to the Conference on Atomic Power and Public Policy. November* 17, 1945. *Standard. Ja.* '46. *p.* 94.

Walter Lippmann has been particularly perceptive in his observations on certain current developments. He has pointed out that with the Nuremburg trials we have, for the first time in history, the attempt to apply effective international law to individual conduct. In the past, international law has always been an affair involving the relations of states; and because of their maintenance of their sovereign power, there has been no way of enforcing this so-called law if the parties to the agreements chose not to enforce them. But in this situation, following the lead of Supreme Court Justice Robert Jackson, we have taken the position that those guilty of waging aggressive warfare in violation of existing international agreements are personally guilty and personally liable. The application of international law to individual human beings is a new thing in the world. And its successful development can not be over-estimated. For it has been said time and again that no world organization of any strength or

promise can be developed unless the people themselves feel a direct tie to it and a direct stake in its success. The more a corpus of law is developed among the nations which affects individuals, therefore, the more their feeling personal involvement will give security to international organization.

This has a great deal to do as well with international control of atomic energy. If agreements or understandings or laws having to do with this control are clearly stated to apply not merely to nations but to individuals, the possibilities of successful international inspection and enforcement are greatly enhanced. To be sure, we cannot say with any certainty that such a system will work. There can be no guarantees in the nature of the case. But in taking our chances in a world of chance, there is a great advantage in knowing that we are taking them in the direction of what we believe to be right. For us to take our chances on increasing military power in this country is dead wrong. And if we have our wits about us we can never permit it to happen. On the other hand, to take our chances on building a world organization that will increase the cooperation of nations, and more importantly, of peoples, is at least to attempt to get our sense of right into the practical situation. It is to give an inner and an ethical sanction to what we are trying to do. From this point of view, the problem of our sharing the secret of the atomic bomb becomes a matter of secondary importance. If we put our trust in an international organization with power, and if it is that international organization's agency which has control over atomic energy, then it will be up to the Soviet Union to decide whether or not it means to go along with such a set-up. It will be up to the Russian people to determine whether or not they are to be part of this family of nations with free inspection systems, and with free exchange of information. If their answer is in the affirmative, the problem becomes relatively simple. If their answer is in the negative, then even though major and extremely difficult problems will still confront us—such as the problem of what attitude and relations an international organization are to maintain toward the Soviet Union—we have the security of knowing that at least we are attempting to solve those problems down the line of what we can honestly say is right.

To do all this means that we have begun to move along the line of intelligent, mature, and cooperative planning. For all the dire warnings that have been issued to us about the dangers of planning, it is obvious that it is indispensable for individuals and for groups or nations insofar as they try to live intelligently. I mention this because in all the furor about what we should do in relation to atomic energy, there is a great inspiration which has been completely overlooked. The inspiration lies in the fact that for the first time in history, a new source of energy has been tapped and people have been trying to think out in advance some of its implications, and what might be done with it for human good. For the first time in history, people have tried to plan the development of something basic. If we look back over the years and ask ourselves what the world might have been like if we had ever taken such an approach to the history of coal when its possibilities were first discovered, or to the usage of oil or electricity, we can see some of the reach of this present activity. In the long run it may prove to be of far greater significance than any specific decisions which may be reached about present problems.

Anyone would be a fool to deny that the atomic bomb and atomic energy are of major importance. What happens to them will of course be a large part of what happens to us. But however large that part is, it is still only a part, and will only partially determine what our future and the futures of our children are to be. The future will really depend upon the *way* in which we deal with this problem of atomic energy, and with all other problems. The attempt to think out solutions in advance, domestically and internationally, the attempt to deal intelligently and cooperatively with such a problem as this, is our greatest hope. And for all the difficulty of the specific problems confronting us, we should never lose sight of the fact that as we now engage in this attempt at mature planning, we are living through one of the most significant and inspiring periods in all human history.—*Jerome Nathanson, Leader of the New York Society for Ethical Culture. "Atomic Power and Public Policy." Address, April* 7, 1946 *mim. p.* 8-9.

CONTROL: NATIONAL AND INTERNATIONAL

ATOMIC ENERGY AND AMERICAN POLICY[1]

On August 6, 1945, when the first atomic bomb was dropped on Japan, President Truman and Secretary of War Stimson both issued statements describing what had been done and revealing the fact that throughout all the years of war there had been a mobilization of science, industry, and military management, the real purpose of which had been kept secret from all but a few leaders. This announcement, and the story of the successful experiment in the New Mexico desert coming at the same time with the news from Japan of the dropping of the bomb on Hiroshima, furnished the greatest single item of news in the world's history.

Both statements showed that the government was aware of the revolutionary nature of the event, and both dealt with the need for future provision by the government "to control the production and use of atomic power within the United States, and also to work out methods for international control." The documents themselves measured up to the epoch-making nature of the subject with which they dealt. Few state papers of any government in modern times can surpass them in human interest and in graphic power of presentation. It is not revealing secrets to comment upon the fact that the scientists themselves who directed the great experiment, also contributed to the description of it and the need for adequate control of atomic energy

President Truman's statement referred only in general terms to the policy of the United States Government with reference to future control of atomic energy. The second part of the document in question read as follows:

[1] By James T. Shotwell, Bryce Professor Emeritus of History of International Relations, Columbia University, Director, Division of Economics and History, Carnegie Endowment for International Peace *International Conciliation.* 416, 751-8 December 1945.

> It has never been the habit of the scientists of this country or the policy of this government to withhold from the world scientific knowledge. Normally, therefore, everything about the work with atomic energy would be made public. But under present circumstances it is not intended to divulge the terminal processes of production or all the military applications, pending further examination of possible methods of protecting us and the rest of the world from the danger of sudden destruction.
>
> I shall recommend that the Congress of the United States consider promptly the establishment of an appropriate commission to control the production and use of atomic power within the United States. I shall give further consideration and make further recommendations to the Congress as to how atomic power can become a powerful and forceful influence toward the maintenance of world peace.

President Truman left it to Secretary Stimson to announce, in connection with his description of the method of control hitherto employed, the steps which had already been taken to prepare for the problem of future control. An interim committee, drawn largely from the Office of Scientific Research and Development, was appointed to consider the uses of atomic energy in both war and peace and to prepare proposals for legislation and policy. The Committee was to make recommendations directly to the President with reference to both national and international control in the whole field of atomic energy, research, and development. Nothing was heard of the work of this Committee in the succeeding weeks and months because it worked with the secrecy which had attended the activities of wartime. Nevertheless it undoubtedly was consulted by both the President and the War Department as they prepared to lay the matter before Congress.

On October 3, President Truman sent his message to Congress calling upon it to enact legislation "to fix a policy with respect to our existing plants and to control all sources of atomic energy and all activities connected with its development and use in the United States." This sweeping directive was further elaborated in the course of the short but epochal message of the President. Congress was properly enough made responsible for defining the system of control for domestic purposes. An atomic energy commission should be set up with members appointed by the President with the advice and consent of the Senate with exceedingly

wide powers of investigation and control of the "use of atomic energy for military, industrial, scientific, or medical purposes."

International arrangements lie properly within the sphere of the executive, and therefore the President's statement to Congress in that regard was in very general terms. Nevertheless, one can already detect in the statement the outlines of subsequent policy. "The hope of civilization lies in international arrangements looking, if possible, to the renunciation of the use and development of the atomic bomb, and directing and encouraging the use of atomic energy and all future scientific information toward peaceful and humanitarian ends" In view of the difficulties in working out such arrangements, the President said that "discussion of the international problem cannot safely be delayed until the United Nations organization is functioning and in a position adequately to deal with it." He announced that there would be discussions in the first place with Great Britain and Canada but that these discussions (limited to those with Great Britain and Canada) would not be concerned with disclosures relating to the manufacturing processes but would "constitute an effort to work out arrangements covering the terms under which international collaboration and exchange of scientific information might safely proceed."

After Congress had met, a bill known as the May-Johnson Bill, was introduced into the House of Representatives by its Military Committee to provide for the domestic control of all matters relating to research and production in the field of atomic energy. This bill was drafted with the primary aim of preventing any leak of information concerning the work of either scientists or industrialists, thus continuing to a large extent the security precautions of wartime. It was immediately attacked by nearly all the scientists who had had any share in the making of the atomic bomb. They formed organizations at the laboratory centers which ultimately grew to include a thousand members, and their opposition to the strict censorship and security control which the army had insisted upon was effective in changing the text of the bill.

Meanwhile the Senators had not been idle. Senator Brien McMahon introduced a bill providing for both domestic and in-

ternational control. There should be a Board at Cabinet level "to develop, control, and supervise the use and application of atomic energy, and material, articles, and commodities derived, obtained, or produced, or manufactured thereby, and to conduct experimentation in that field" The Board was also to furnish the link with the Security Council of the United Nations. Article Six of the Bill, which dealt with this vital question, read as follows:

> The Board is authorized to empower the representatives of the United States to the Security Council of the United Nations to enter into agreements with the Security Council by which the United States shall license the Security Council to sponsor, undertake, and conduct experimentation, research, and studies in the production, use, and application of atomic energy, or shall undertake to furnish to authorized representatives of the Security Council information concerning the production, use, and application of atomic energy on such terms and conditions as the Board shall prescribe In addition to such other terms and conditions as the Board deems wise, any such agreement or undertaking shall provide that all other Members of the United Nations shall turn over and make available to the Security Council all information of whatsoever kind possessed by them concerning research and development in the field of armament and munitions of war, and that representatives of the Security Council shall be authorized to have access to and inspect all plants, laboratories, and operations of whatsoever kind relating to research, development, manufacture, and production of armament and munitions of war. Any agreement entered into pursuant to the provisions of this section shall be reported to the Congress by the President and shall not become effective until approved by an act of Congress—(S. 1359, section 6).

An important initial question arose as to which Committee of the Senate should undertake the preparation of appropriate legislation of this character. After discussion it was agreed that none of the standing committees of the Senate had been designed to cover so wide a field which included not only the international aspects of security but the whole problem of domestic control. Senator Vandenberg had previously made this point with especial emphasis in the earlier phases of the discussion. Finally it was decided to create a Special Committee on Atomic Energy, and Senator McMahon was chosen to be Chairman of it. This Committee, which will therefore have the leadership in the shaping of legislation in the Senate, started its work by a

procedure which is unique in the history of Congress. Its members literally went to school to the scientists to acquire authoritative basic knowledge of the fundamentals of the problems of atomic energy. It is a procedure to be commended and it is to be hoped it may furnish a precedent for other subsequent developments in the adaptation of national policy to the exigencies of science.

In this connection it is interesting to see that the British Government has taken steps similar to those proposed in Washington, by setting up an advisory committee on atomic energy under the chairmanship of Sir John Anderson, the Member of Parliament for the Scottish Universities. This advisory committee, according to a statement of Prime Minister Attlee on October 30, recommended the establishment of a research and experimental establishment station covering all aspects of the use of atomic energy. The government immediately acted upon this proposal and set up an establishment at Harwell airfield near Oxford. It was further decided, in view of the importance of this work to the Service Departments, to transfer the responsibility for research from the Department of Scientific and Industrial Research, on which the scientists have been at work, to the Ministry of Supply, with a representation of scientists on both the advisory committee and its technical subcommittees.

On October 27, President Truman laid down the fundamentals of our foreign policy in the Twelve Points of his Navy Day speech. Contrary to popular impression, this speech did not deal with the ultimate disposition of the "secret" of the atomic bomb. The President himself emphasized the fact that he was merely repeating what he had already said in his message to Congress when he announced that the United States would discuss the atomic bomb with Great Britain and Canada and later with other nations, but then went on to say that these discussions would not be concerned with the processes of manufacturing the atomic bomb or any other instruments of war. It was in this connection, with reference to the delay in any final disposition of the "secret," that the President referred to it as a "sacred trust" of the United States. The passage in which this phrase occurred is one which was undoubtedly designed to pre-

vent any misunderstanding or apprehension as to the purposes of the United States, which are those of world peace. "Because of our love of peace, the thoughtful people of the world know that that trust will not be violated, that it will be faithfully executed." Unfortunately the realists in other nations have not been completely reassured by this statement, which in the eyes of its critics was taken to imply an unwillingness to cooperate in the greatest single test which could ever be made of the world-wide reduction of armaments. On the other hand, it must be evident that the President did not say that the United States was going to keep the secret indefinitely, an impossibility in any case, but was dealing only with the period of transition between present conditions and those when there could be adequate safeguards by international organization.

The next document came from Moscow. Foreign Commissar Molotov's speech on November 6 dealt mainly with Russia's domestic problems in the unsettled postwar world. There were two references, however, to atomic energy, one in connection with its use for security and the other with reference to the progress of technology. These two references are separated by fully half of the text of the long address. As they are the only official statements we have yet had from Soviet Russia, the text of the two references should be kept in mind in connection with our own problem.

The first reference, that bearing upon the problems of security, occurs in connection with a warning against a race in armaments which would result from a return to the discredited Balance of Power policy. There is also a reminder that Moscow has a clear memory of past blocs formed against it, although that history is not referred to in detail. The extract runs as follows:

> In this connection, a word must be said about the discovery of atomic energy and about the atomic bomb, the colossal destructive force of which was displayed in the war against Japan.
>
> Atomic energy has not yet been tried, however, for averting aggression or safeguarding peace. But it is not possible at the present time for a technical secret of any great size to remain the exclusive possession of some one country or some narrow circle of countries.

This being so, the discovery of atomic energy should not encourage either a propensity to exploit the discovery in the play of forces in international policy or an attitude of complacency as regards the future of the peace-loving nations.

A good deal of noise is also being made about the formation of blocs or groups of states as an end of particular foreign policy interests. The Soviet Union has never joined groups of powers directed against other peaceable states.

In the West, however, attempts of this kind have been made, as is generally known, more than once The anti-Soviet nature of certain such groups in the past is equally well known. In any case, the history of blocs and groups of the western powers indicates that they do not tend to bridle aggressors, but on the contrary to encourage aggression, particularly on the part of Germany

Hence there must be no relaxation in the vigilance of the Soviet Union and other peaceful states on this score. The restoration of world peace has by no means led, and could not have led, to a restoration of the prewar position in international relations.

The second reference to atomic energy in Commissar Molotov's address comes at the close when he turns from the problems of security to those of welfare. It should not escape our attention that this is the one section of the address in which there is a definite statement of what Soviet Russia intends to do. That statement is confined to the productive economic uses of atomic energy for peaceful purposes:

In our days of advance technology and extended employment of science in production where it has become possible to harness atomic energy and other great technical discoveries, attention in economic planning must be focused on problems of technology, on the problem of raising the technological power of our industry and training highly skilled technological trainers. We must keep level with the achievements of present-day world technology in all branches of industry and economic life and provide conditions for the utmost advance of Soviet science and technology.

The enemy interrupted our peaceful creative endeavor, but we shall make up properly for all lost time and see to it that our country shall flourish. We will have atomic energy and many other things, too.

Let us tackle these tasks with all our inexhaustible Bolshevik energy, with all the boundless energy of the Soviet people. Let us work as Comrade Stalin teaches us to do.

The first phase of negotiations for the clarification of policy on the part of the United States, Great Britain, and Canada

extended over a week's discussion at Washington, participated in by the Prime Minister of Great Britain and Canada, Mr. Attlee and Mr. King, with the President, the Secretary of State, and a technical staff. The results of these negotiations are set forth in the communique, issued November 15. . . .

This important document has been the subject of much discussion in the three participating countries. With reference to the proposal that "a Commission should be set up under the United Nations Organization to prepare recommendations for submission to the Organization" it was urged by commentators that there should in no case be delay in setting up the Commission. This point was strongly made by Mr Anthony Eden in his speech in Parliament on November 22. But President Truman had already answered the objection in a news conference on November 20 with the definite proposal that the Commission should be appointed by the Assembly, at its first meeting.

SAFEGUARDING ATOMIC ENERGY AGAINST MISUSE [2]

I have been asked to speak to you briefly about the report of the Secretary of State's Committee on Atomic Energy. The Committee felt that what was most needed at the outset was to get a group of qualified consultants who would be willing to give their full time for a long enough period to make a really thorough analysis of the problems of international control. And so at the beginning of our work we appointed a Board of Consultants consisting of Dr. J. Robert Oppenheimer, one of the chief physicists of the Manhattan Project, and three leading industrialists, Chester Barnard of the New Jersey Bell Telephone Co., Dr. Charles Thomas of the Monsanto Chemical Co. and Harry Winne of the General Electric Co. The group was headed by David Lilienthal of the Tennessee Valley Authority.

These gentlemen visited the plants at Oak Ridge and Los Alamos. They spent many weeks discussing all matters relat-

[2] Address by Dean Acheson, Under Secretary of State; chairman of the Secretary of State's Committee on Atomic Energy, before the American Society of Newspaper Editors, April 20, 1946. *United States News*, 20:57-9. May 3, 1946.

ing to the manufacture of the fissionable materials, the controls that would be necessary, to what extent the manufacture could safely be left to individual nations or must be under international control, and they formed certain conclusions. These conclusions grew out of the facts as they found them to be. Their first conclusion was that one widely discussed conception was pure moonshine. This was the conception that atomic energy could be controlled initially by the various nations of the world acting under some sort of agreement that would, in common parlance, outlaw the use of atomic energy for warlike purposes, with an international inspection force policing atomic energy research and development everywhere. It seemed perfectly clear to the consultants that any such attempt was not only doomed to failure, but to worse than failure, because it would encourage people everywhere to believe that it provided security, when, in fact, there would be no security at all. The reason that they thought that there would be no security at all was that the very conception of having fissionable materials—that is, the materials from which you get atomic energy—produced independently by nations meant, in the first place, that those who produced these materials would know far more than those who were trying to police them. That would necessarily be so. It would also necessarily be so that whatever various nations learned in the course of their work they would keep secret. It would also be true that there would be great rivalry for the control and the possession of the source ores needed for the manufacture of fissionable materials.

You would, therefore, have what in our discussions we used to refer to as the cops-and-robbers theory of control. You would have various nations highly equipped with the best scientists in the world, with whatever factories they were able to provide, engaged in intense rivalry to obtain source materials and make fissionable materials. Internationally, you would have a group of people charged with policing the agreement outlawing these activities who couldn't possibly know as much as those whom they were trying to police. These policemen would be looking for factories or plants even the design of which they would not know.

Something else about the arrangement would be even worse. It is this: What the policemen would be looking for would be a state of mind. In getting raw materials and in the manufacture of fissionable materials, whether you wish to use them for warlike purposes or whether you wish to use them for peaceful purposes, everything that you do is very much the same up to the time when you come to construct the bomb So whatever you find, you have discovered nothing until you have discovered the state of mind.

If you find a mine producing uranium or a factory producing U-235 or plutonium, you will discover nothing, because those in charge of that activity will always insist that they are engaged in it for peaceful purposes Even if you discover a shop or factory where somebody is trying to put together a bomb, you will discover nothing, because the person who is doing it will say: "I am doing this for experimental purposes." So such policing seemed to the consultants to be entirely futile and hopeless.

The consultants then went on with their investigation of the facts and came to the following conclusions, out of which the outline of their plan of control began to emerge:

They concluded, in the first place, that there is only one material which is indispensable to the production of atomic energy, and that element is uranium. There is no way, in the opinion of the Committee and of the Board of Consultants, by which such production can be achieved without uranium. They concluded also that there is another element of great importance, thorium, provided you have uranium to begin with. This was an important conclusion because it led them to believe that if there were ways of controlling uranium and thorium through some international organization, you have begun to get your hands on the key to international control.

This conclusion was strengthened by the fact that in many instances these two elements occur together, in sufficiently rich deposits, in fairly well known types of geological formation and not too frequently in the world. Of course, the elements also occur in thinner deposits. Uranium occurs in almost infinitesimal degrees in every part of the earth's crust, but at the

present time no one knows how to work the material found in minute quantities. Therefore, looking at the facts concerning raw materials, you begin to see the question of international control within measurable proportions. You are not faced by the insurmountable problem of an army of inspectors who would have to look into every activity in every part of the world to see if anyone was doing anything on nuclear fission with a warlike intent. Here was something more manageable, which it might be possible to control.

Then the consultants went further. They said: "What happens after you produce the raw materials?" The next thing that happens is the production of fissionable materials—U-235 or plutonium. They concluded that that was, from the point of view of international security, an inherently dangerous operation. That, too, was something which could not be left freely in the hands of individual nations or individual enterprises.

The consultants then went a little further and asked: "What else do we find to be dangerous?" They found that the production of explosives themselves was perhaps the most dangerous activity of all.

So they emerged with these three central points: the production of the raw material of the two elements, uranium and thorium; the manufacture of those raw materials into actual fissionable material which could be used for explosives; and the production of explosives. All those activities, the consultants said, are dangerous.

Then the board of consultants asked: "Are there other activities which are important?" They agreed that there are others which are very important. These other activities happen also to be those which are immensely promising in the use of atomic energy for peaceful purposes. There is the use of radioactive tracer materials. This is perhaps the most promising of all the uses of atomic energy. Used, for example, in research in regard to the human body, in regard to all vegetable and animal matter, you have a tremendous opportunity of tracing all the various reactions which occur in living organisms and in that

way learning more about these reactions than could possibly be learned in any other way.

Now that is not a dangerous activity. It is not dangerous because the amounts of fissionable material used in any one of these research operations is so small that if you put together all that would be needed for research in one country, or even in several countries, you still would not have enough material to do any harm.

Then, the consultants said, there are other activities which are not dangerous. Such another activity is the operation of small reactors, which in turn produce radioactive tracer materials or which are used for experimental and testing purposes in industry or in chemical, physical or biological research. Again, this activity is not dangerous because there would not be enough material in one or a dozen of them to do any harm.

There is still another activity full of promise for the future, and that is the production of power. Here you begin to approach the field of danger, because in the reactor that will make power you will need so much of the fissionable material that it might be dangerous. Even so, the consultants believe that by care in designing reactors a large measure of safety could be achieved. Moreover, the consultants studied this matter further, and concluded—and I think this is in line with the concensus of scientific opinion—that by denaturing the fissionable material an additional safeguard could be provided.

Now, when this conclusion in the report first became known, it was taken up and distorted. People like to make things seem simpler than they often are So they quickly jumped to a conclusion that we in our discussions referred to as the theory of the good and the bad fairy The bad fairy set out to destroy the world, and the good fairy came and waved her wand, and the world was not destroyed; no harm was done. That is not a correct reflection of the facts What the consultants say in their report is that these fissionable materials can be so processed or treated after they are produced that only by a major industrial effort can they be processed further so as to be used effectively in explosives. That doesn't mean that it can't be done. It means that it is a very difficult job to do.

What is the significance of this? Its sole significance is that it makes it safer than it otherwise would be to permit a rather broad use by nations or by individuals of fissionable materials in the production of power.

Now, with these conclusions before them, the consultants went back, set forth what they regarded as the essential facts and came out with their report. As the Secretary of State said in his foreword, it is not a statement of government policy. It is purely a working paper for the consideration of those who have to determine government policy. The proposal is that by agreement among all the nations of the world the raw materials of uranium and thorium shall be in the hands of an international organization created by treaty, with powers and functions very specifically spelled out in the treaty. Wherever uranium and thorium occur in useful quantities, they shall as a matter of treaty right be under the control of the international organization. The international organization shall have the sole right to work these materials and to produce them. It may do the work itself or it may have other agencies carry on operations for it. The important thing is that it shall have the right to determine how the exploitation is done, because it is only by having the managerial authority, the complete power of direction, that there can be any effective accounting and control, so these materials will not be permitted to escape into dangerous channels.

Now, you immediately begin to get international control more nearly within more practical bounds and limits. Under the arrangements contemplated by the consultants, anyone who is inspecting is not looking for a state of mind; he is looking for an activity. When he finds the prohibited activity, he knows that a treaty has been violated, and he knows that trouble is brewing, and he can say so. If some person or some nation is producing uranium and thorium, it doesn't make any difference what their state of mind may be. And if uranium and thorium are being produced, the fact can be readily ascertained, because the international organization in the ordinary course of its business is sending its prospectors into all countries of the world and discovering through geological exploration where the

sources of uranium and thorium are. Should the inspectors see new holes in the ground opening up, they would inquire into the reasons. Without being a group of prohibition enforcement officers prying into everybody's business, they can in the conduct of their own business find out what is going on.

Then the report proceeds to say that the second dangerous step—the production of fissionable material—must also be within the control of the international organization. This is a highly dangerous step The international organization must be the only organization which produces fissionable material. Again, if the inspectors or the personnel of the international organization discover or hear about or have instruments which record the existence in any part of the world of a building, a factory or a plant producing fissionable materials, those are illegal activities, and the world is put on notice.

The suggestion is made in the report that the treaty spell out how fissionable materials are to be produced. For the most part, they can be produced in such form that the final product cannot, without additional effort, be used to make explosives. The plants which produce these materials can produce, also, a great amount of power. It is estimated that half of the power that would be produced through atomic energy could be produced in these primary plants which produce fissionable materials. It would be produced in the plants of the international organization but would be turned over to the nation in which it was produced, for disposition according to that nation's policies.

It is also stated in the report that it is desirable that these plants be so distributed about the world that there can be no thought in the mind of any party to the treaty that the strength which would come from having these plants is concentrated in one country. They should be so scattered about that there would be no temptation on the part of anybody to gain a monopoly within the borders of a single nation.

Now, of course, there is a possibility of danger in this situation. Everyone understands that a nation that has decided to violate the treaty might send its soldiers in and take over a plant operating under the international organization. The organiza-

tion would be quite powerless to prevent that, because no one can resist the force of a great power within its own borders. The plan is not designed to prevent that. It is so set up that, if such a development should take place, it would constitute a clear, out-and-out, notorious violation of the treaty, and all the world would be put on notice that the nation involved is embarking on an aggressive policy that must inevitably lead to trouble. The world is also put on notice in sufficient time so that the other nations can make their dispositions and be ready for trouble.

The consultants estimate that any nation taking such action with one of these plants would not be in a position, within one year and possibly not within two or three years to use what it had captured to make actually dangerous amounts of explosive material. The reason is that the nature of plants would be such that, in order to produce explosive material, there would have to be major additional production and additional construction, and that would take a long enough time so that the world could be ready.

Then the report goes on to suggest that the nondangerous activities should be licensed by the international authority under a system which would prescribe the actual construction of the reactor or plant or whatever it may be that would use the fissionable material. Suppose, for instance, that you wish to use some of this material for the production of power. Now, note that the production of power in this secondary use is different from the production of the power in the primary use, because in the primary factor you are both producing power and producing fissionable materials. In the second type of factory, the nondangerous factory, you are taking the fissionable material and using it as a sort of fuel, something which is consumed and used up. In that type of plant, a license can be issued to build a certain kind of reactor. The license would describe how it should be constructed, the authority would supervise its construction, and it would be so constructed that you could not get the fissionable material out of it to make bombs or more fissionable materials except by tearing it to pieces. It is no great trick to supervise that sort of plant, because all you have to do is

look at the power dials. If the plant is producing power and the fissionable material is inside it, it will show on the dials. It it is not producing power, something suspicious has happened.

A nation could of course tear one of these plants apart. Again, if the other parts of your control system were effective, it would take at least a year and possibly longer to take the denatured material, build a factory to produce something from it and use it for hostile purposes.

The report then recommends that the international authority should be in the forefront of experimentation in the field of explosives Some people have asked me: why not forget all that? Why not say that nobody may do it? To say that is, again, to enter into the field of illusion. It is only by knowing more about developments than anyone else that this international authority can stay in the forefront. It can get nowhere by knowing nothing If you were in the forefront of experimentation, then you would know what dangerous things could be developed and what to look for.

That is the general plan that the board of consultants has put forward. Its members know that there are tremendous difficulties of all sorts in this plan. All of us regard it as one would regard a preliminary sketch by an architect of a building which he wishes to build, as distinguished from the final blueprints which have all the construction and all the plumbing and all the material set forth in detail. There are hundreds of problems lurking in this field, and all of these problems must be worked out in detail by a competent and extensive staff.

I might add that the consultants in making their report were quite conscious of the difficulties of negotiation lying ahead. They did not undertake to go into that field. There is much latitude in this plan. There is latitude in the speed with which you move from one step to another. The board has recommended that we begin, as Alice in Wonderland said, at the beginning and not at the end. The beginning is the field of raw materials It is a vast field. It will take a long time to organize it, to get the staff that is necessary, to be sure that you have the cooperation of all nations engaged in this plan before you agree to other steps. Nobody would dream of tak-

ing the other steps unless you were satisfied that this first one could be done effectively.

There is one thing which I believe the board feels very strongly about. That is the plan of interlocking safeguards. There is no one part of this plan which alone gives any security whatever. The security comes entirely from the fact that you have at each stage a remaining measure of protection. The raw materials may, to be sure, be captured. They may be surreptitiously mined. If they are, and the violation is not caught at that stage, then you have another safeguard in the second step,—that only the authority can process those materials. So you have a second chance to catch violators. Then, of course, there is the third step.

One of the most dangerous things in the world, obviously, would be to start with a plan like this and in the course of negotiations make concessions that would weaken the safeguards at any point. If that were done, it would be far better that this plan had never been thought of. This particular plan is one that rests on the maintenance of all its interlocking safeguards.

Whether or not it is accepted is not the concern of the board of consultants or the Committee. The Committee has done what the Secretary of State has asked it to do, which is to get a study completed and lay it before those who have the responsibility for policy. The Committee and the board have, I think, discharged that duty, and all the members stand ready to be of any service in the future. But there is one more thing that has been done; that is to direct attention to the realities of this problem and away from the loose talk which was going on before. There was a lot of talk before that seemed to be based on the assumption that the pre-eminence of the United States in this field rests on certain secrets that were locked up in General Groves' desk.

That is not the situation at all A debate on that basis is futile and ill-informed. The American pre-eminence in this field has a much more solid foundation than that. Of course, one part of the foundation is based on the fact that this country is in the forefront of scientific knowledge. But it isn't going to be in the forefront very long. Any scientist who proceeds from

the past into the future must reach the same discoveries. American pre-eminence rests on something more solid than that, and that is that there is a tremendous wealth of technological knowledge in this country. We know how to take laboratory problems and put them into factories stretching over dozens of square miles. We have the industrial civilization here which can take those technological blueprints and translate them into action. We have access to the raw materials. These are the solid bases of American pre-eminence, not merely the fact that we know something other people don't know

So I think that the Committee and the board of consultants, even if the plan should ultimately be regarded as not desirable, have performed a useful service in directing attention to some of the realities of the problem and away from the dialectics.

ATOMIC ENERGY CONTROL [8]

We are here to make a choice between the quick and the dead

That is our business.

Behind the black portent of the new atomic age lies a hope which, seized upon with faith, can work our salvation. If we fail, then we have damned every man to be the slave of fear. Let us not deceive ourselves: We must elect world peace or world destruction.

Science has torn from nature a secret so vast in its potentialities that our minds cower from the terror it creates. Yet terror is not enough to inhibit the use of the atomic bomb. The terror created by weapons has never stopped man from employing them. For each new weapon a defense has been produced, in time. But now we face a condition in which adequate defense does not exist.

Science, which gave us this dread power, shows that it can be made a giant help to humanity, but science does not show us how to prevent its baleful use. So we have been appointed

[8] Address of Bernard M Baruch, United States Representative to the United Nations Atomic Energy Commission, at opening session, June 14, 1946. *Congressional Record*. 92.(daily)A3703-5. June 17, 1946.

to obviate that peril by finding a meeting of the minds and the hearts of our peoples. Only in the will of mankind lies the answer.

It is to express this will and make it effective that we have been assembled. We must provide the mechanism to assure that atomic energy is used for peaceful purposes and preclude its use in war. To that end, we must provide immediate, swift, and sure punishment of those who violate the agreements that are reached by the nations.

Penalization is essential if peace is to be more than a feverish interlude between wars. And, too, the United Nations can prescribe individual responsibility and punishment on the principles applied at Nuremberg by the Union of Soviet Socialist Republics, the United Kingdom, France, and the United States—a formula certain to benefit the world's future.

In this crisis, we represent not only our governments but, in a larger way, we represent the peoples of the world. We must remember that the peoples do not belong to the governments, but that the governments belong to the peoples. We must answer their demands; we must answer the world's longing for peace and security.

In that desire the United States shares ardently and hopefully, the search of science for the absolute weapon has reached fruition in this country. But she stands ready to prescribe and destroy this instrument—to lift its use from death to life—if the world will join in a pact to that end.

In our success lies the promise of a new life, freed from the heart-stopping fears that now beset the world. The beginning of victory for the great ideals for which millions have bled and died lies in building a workable plan. Now we approach fulfillment of the aspirations of mankind. At the end of the road lies the fairer, better, surer life we crave and mean to have.

Only by a lasting peace are liberties and democracies strengthened and deepened. War is their enemy. And it will not do to believe that any of us can escape war's devastation. Victory, vanquished and neutrals alike, are affected physically, economically, and morally.

Against the degradation of war we can erect a safeguard. That is the guerdon for which we reach. Within the scope of the formula we outline here there will be found, to those who seek it, the essential elements of our purpose. Others will see only emptiness. Each of us carries his own mirror, in which is reflected hope—or determined desperation—courage, or cowardice.

There is a famine throughout the world today. It starves men's bodies But there is a greater famine—the hunger of men's spirit That starvation can be cured by the conquest of fear and the substitution of hope, from which springs faith—faith in each other, faith that we want to work together toward salvation; and determination that those who threaten the peace and safety shall be punished.

The peoples of these democracies gathered here have a particular concern with our answer, for their peoples hate war. They will have a heavy exaction to make of those who fail to provide an escape. They are not afraid of an internationalism that protects; they are unwilling to be fobbed off by mouthings about narrow sovereignty, which is today's phrase for yesterday's isolation.

The basis of a sound foreign policy in this new age for all the nations here gathered is that: Anything that happens, no matter where or how, which menaces the peace of the world, or the economic stability, concerns each and all of us.

That roughly may be said to be the central theme of the United Nations It is with that thought we begin consideration of the most important subject that can engage mankind—life itself.

Let there be no quibbling about the duty and the responsibility of this group and of the governments we represent. I was moved, in the afternoon of my life, to add my effort to gain the world's quest, by the broad mandate under which we were created. The resolution of the General Assembly, passed January 24, 1946, in London, reads:

> Section V. Terms of reference of the Commission:
>
> The Commission shall proceed with the utmost dispatch and inquire into all phases of the problem, and make such recommendations from time to time with respect to them as it finds possible.

In particular the Commission shall make specific proposals:

A. For extending between all nations the exchange of basic scientific information for peaceful ends;

B. For control of atomic energy to the extent necessary to insure its use only for peaceful purposes;

C. For the elimination from national armaments of atomic weapons and of all other major weapons adaptable to mass destruction;

D For effective safeguards by way of inspection and other means to protect complying states against the hazards of violations and evasions

The work of the Commission should proceed by separate stages, the successful completion of each of which will develop the necessary confidence of the world before the next stage is undertaken.

Our mandate rests, in text and in spirit, upon the outcome of the conference in Moscow of Messrs. Molotov, of the Union of Soviet Socialist Republics; Bevin, of the United Kingdom; and Byrnes of the United States of America. The three Foreign Ministers, on December 27, 1945, proposed the establishment of this body.

Their action was animated by a preceding conference in Washington on November 15, 1945, when the President of the United States, associated with Mr. Attlee, Prime Minister of the United Kingdom, and Mr. Mackenzie King, Prime Minister of Canada, stated that international control of the whole field of atomic energy was immediately essential. They proposed the formation of this body. In examining that source, the agreed declaration, it will be found that the fathers of the concept recognized the final means of world salvation—the abolition of war. Solemnly they wrote:

We are aware that the only complete protection for the civilized world from the destructive use of scientific knowledge lies in the prevention of war. No system of safeguards that can be devised will of itself provide an effective guaranty against production of atomic weapons by a nation bent on aggression. Nor can we ignore the possibility of the development of other weapons, or of new methods of warfare, which may constitute as great a threat to civilization as the military use of atomic energy.

Through the historical approach I have outlined, we find ourselves here to test if man can produce, through his will and faith, the miracle of peace, just as he has, through science and skill, the miracle of the atom.

The United States proposes the creation of an international atomic development authority, to which should be entrusted all phases of the development and use of atomic energy, starting with the raw material and including:

1. Managerial control or ownership of all atomic energy activities potentially dangerous to world security.

2. Power to control, inspect, and license all other atomic activities.

3. The duty of fostering the beneficial uses of atomic energy.

4. Research and development responsibilities of an affirmative character intended to put the authority in the forefront of atomic knowledge and thus to enable it to comprehend, and therefor to detect, misuse of atomic energy. To be effective, the authority must itself be the world's leader in the field of atomic knowledge and development and thus supplement its legal authority with the great power inherent in possession of leadership in knowledge.

I offer this as a basis for beginning our discussion.

But I think the peoples we serve would not believe—and without faith nothing counts—that a treaty, merely outlawing possession or use of the atomic bomb constitutes effective fulfillment of the instructions to this commission Previous failures have been recorded in trying the method of simple renunciation, unsupported by effective guaranties of security and armament limitation. No one would have faith in that approach alone.

Now, if ever, is the time to act for the common good. Public opinion supports a world movement toward security. If I read the signs aright the people want a program not composed merely of pious thoughts but of enforceable sanctions—an international law with teeth in it.

We of this nation desirous of helping to bring peace to the world and realizing the heavy obligations upon us, arising from our possession of the means of producing the bomb and from the fact that it is part of our armament, are prepared to make our full contribution toward effective control of atomic energy.

When an adequate system of atomic energy, including the renunciation of the bomb as a weapon, has been agreed upon and put into effective operation and condign punishments set up for violations of the rules of control which are to be stigmatized as international crimes, we propose that:

1. Manufacture of atomic bombs shall stop;

2. Existing bombs shall be disposed of pursuant to the terms of the treaty; and

3. The authority shall be in possession of full information as to the know-how for the production of atomic energy.

Let me repeat, so as to avoid misunderstanding: My country is ready to make its full contribution toward the end we seek, subject, of course, to our constitutional processes, and to an adequate system of control becoming fully effective as we finally work it out.

Now as to violations: In the agreement, penalties of as serious a nature as the nations may wish and as immediate and certain in their execution as possible, should be fixed for:

1. Illegal possession or use of an atomic bomb;

2. Illegal possession or separation of atomic material suitable for use in an atomic bomb;

3. Seizure of any plant or other property belonging to or licensed by the authority;

4. Willful interference with the activities of the authority;

5. Creation or operation of dangerous projects in a manner contrary to, or in the absence of, a license granted by the international control body.

It would be a deception, to which I am unwilling to lend myself, were I not to say to you and to our peoples that the matter of punishment lies at the very heart of our present security system. It might as well be admitted, here and now, that the subject goes straight to the veto power contained in the Charter of the United Nations so far as it relates to the field of atomic energy. The Charter permits penalization only by concurrence of each of the five great powers—Union of Soviet Socialist Republics, the United Kingdom, China, France, and the United States.

I want to make this very plain that I am concerned here with the veto power only as it affects this particular problem. There must be no veto to protect those who violate their solemn agreements not to develop or use atomic energy for destructive purposes.

The bomb does not wait upon debate. To delay may be to die The time between violation and preventive action or punishment would be all too short for extended discussion as to the course to be followed.

As matters now stand, several years may be necessary for another country to produce a bomb de novo. However, once the basic information is generally known, and the authority has established producing plants for peaceful purposes in the several countries, an illegal seizure of such a plant might permit a malevolent nation to produce a bomb in twelve months, and if preceded by secret preparation and necessary facilities perhaps even in a much shorter time. The time required—the advance warning given of the possible use of a bomb—can only be generally estimated but obviously will depend upon many factors, including the success with which the authority has been able to introduce elements of safety in the design of its plants and the degree to which illegal and secret preparation for the military use of atomic energy will have been eliminated. Presumably no nation would think of starting a war with only one bomb.

This shows how imperative speed is in detecting and penalizing violations.

The process of prevention and penalization—a problem of profound statecraft is, as I read it, implicit in the Moscow statement, signed by the Union of Soviet Socialist Republics, the United States, and the United Kingdom a few months ago.

But before a country is ready to relinquish any winning weapons it must have more than words to reassure it. It must have a guaranty of safety not only against the offenders in the atomic area but against the illegal users of other weapons—bacteriological, biological, gas, perhaps, why not? against war itself.

In the elimination of war lies our solution, for only then will nations cease to compete with one another in the production

and use of dread secret weapons which are evaluated solely by their capacity to kill. This devilish program takes us back not merely to the Dark Ages but from cosmos to chaos. If we succeed in finding a suitable way to control atomic weapons, it is reasonable to hope that we may also preclude the use of other weapons adaptable to mass destruction. When a man learns to say "a" he can if he chooses, learn the rest of the alphabet, too.

Let this be anchored in our minds:

Peace is never long preserved by weight of metal or by an armament race. Peace can be made tranquil and secure only by understanding an agreement fortified by sanctions. We must embrace international cooperation or international disintegration.

Science has taught us how to put the atom to work. But to make it work for good instead of for evil lies in the domain dealing with the principles of human duty. We are now facing a problem more of ethics than of physics.

The solution will require apparent sacrifice in pride and in position, but better pain as the price of peace than death as the price of war.

I now submit the following measures as representing the fundamental features of a plan which would give effect to certain of the conclusions which I have epitomized.

1. General: The authority should set up a thorough plan for control of the field of atomic energy, through various forms of ownership, dominion, licenses, operation, inspection, research, and management by competent personnel. After this is provided for there should be as little interference as may be with the economic plans and the present private, corporate, and state relationships in the several countries involved.

2. Raw materials: The authority should have as one of its earliest purposes to obtain and maintain complete and accurate information on world supplies of uranium and thorium and to bring them under its domination. The precise pattern of control for various types of deposits of such materials will have to depend upon the geological, mining, refining, and economic facts involved in different situations.

The authority should conduct continuous surveys so that it will have the most complete knowledge of the world geology of

uranium and thorium. Only after all current information on world sources of uranium and thorium is known to us all can equitable plans be made for their production, refining, and distribution.

3. Primary production plants: The authority should exercise complete managerial control of the production of fissionable materials. This means that it should control and operate all plants producing fissionable materials in dangerous quantities and must own and control the product of these plants.

4. Atomic explosives: The authority should be given sole and exclusive right to conduct research in the field of atomic explosives. Research activities in the field of atomic explosives are essential in order that the authority may keep in the forefront of knowledge in the field of atomic energy and fulfill the objective of preventing illicit manufacture of bombs. Only by maintaining its position as the best informed agency will the authority be able to determine the line between intrinsically dangerous and nondangerous activities.

5. Strategic distribution of activities and materials: The activities entrusted exclusively to the authority because they are intrinsically dangerous to security should be distributed through the world. Similarly, stock piles of raw materials and fissionable materials should not be centralized.

6. Nondangerous activities: Function of the authority should be promotion of the peacetime benefits of atomic energy.

Atomic research (except in explosives) the use of research reactors, the production of radioactive tracers by means of nondangerous reactors, the use of such tracers, and to some extent the production of power should be open to nations and their citizens under reasonable licensing arrangements from the authority. Denatured materials, whose use we know also require suitable safeguards, should be furnished for such purposes by the authority under lease or other arangement. Denaturing seems to have been overestimated by the public as a safety measure.

7. Definition of dangerous and nondangerous activities: Although a reasonable dividing line can be drawn between dangerous and nondangerous activities it is not hard and fast. Provision should, therefore, be made to assure constant reexamina-

tion of the questions and to permit revision of the dividing line as changing conditions and new discoveries may require.

8. Operations of dangerous activities—any plant dealing with uranium or thorium after it once reaches the potential of dangerous use must be not only subject to the most rigorous and competent inspection by the authority, but its actual operation shall be under the management, supervision, and control of the authority.

9. Inspection: By assigning intrinsically dangerous activities exclusively to the authority, the difficulties of inspection to the authority, the difficulties of inspection are reduced. If the authority is the only agency which may lawfully conduct dangerous activities, then visible operation by others than the authority will constitute an unambiguous danger signal. Inspection will also occur in connection with the licensing functions of the authority.

10. Freedom of access: Adequate ingress and egress for all qualified representatives of the authority must be assured. Many of the inspection activities of the authority should grow out of, and be incidental to, its other functions.

Important measures of inspection will be associated with the tight control of raw materials, for this is a keystone of the plan. The continuing activities of prospecting, survey, and research in relation to raw materials will be designed not only to serve the affirmative development functions of the authority, but also to assure that no surreptitious operations are conducted in the raw materials field by nations or their citizens.

11. Personnel: The personnel of the authority should be recruited on a basis of proven competence, but also so far as possible on an international basis.

12. Progress by stages: A primary step in the creation of the system of control is the setting forth, in comprehensive terms of the functions, responsibilities, powers, and limitations of the authority.

Once a charter for the authority has been adopted, the authority and the system of control for which it will be responsible will require time to become fully organized and effective. The plan of control will, therefore, have to come into effect in successive stages.

These should be specifically fixed in the Charter or means should be otherwise set forth in the Charter for transitions from one stage to another, as contemplated in the resolution of the United Nations Assembly which created this commission.

13. Disclosures: In the deliberations of the United Nations Commission on Atomic Energy, the United States is prepared to make available the information, essential to a reasonable understanding of the proposals which it advocates. Further disclosures must be dependent, in the interests of all, upon the effective ratification of the treaty.

When the authority is actually created, the United States will join the other nations in making available the further information essential to that organization for the performance of its functions. As the successive stages of international control are reached, the United States will be prepared to yield, to the extent required by each stage, national control of activities in this field to the authority.

14. International control: There will be questions about the extent of control to be allowed to national bodies when the authority is established. Purely national authorities for control and development of atomic energy should, to the extent necessary for the effective operation of the authority, be subordinate to it. This is neither an endorsement nor a disapproval of the creation of national authorities. The Commission should evolve a clear demarcation of the scope of duties and responsibilities of such national authorities.

And now I end. I have submitted an outline for present discussion. Our consideration will be broadened by the criticism of the United States proposals and by the plans of the other nations, which, it is to be hoped, will be submitted at their early convenience. I and my associates of the United States delegation will make available to each member of this body books and pamphlets, including the Acheson-Lilienthal report, recently made by the United States Department of State, and the McMahon committee monograph No. 1, entitled "Essential Information on Atomic Energy," relating to the McMahon bill recently passed by the United States Senate, which may prove of value in assessing the situation.

All of us are consecrated to making an end of gloom and hopelessness It will not be an easy job. The way is long and thorny, but supremely worth traveling. All of us want to stand erect, with our faces to the sun, instead of being forced to burrow into the earth, like rats.

The pattern of salvation must be worked out by all for all.

The light at the end of the tunnel is dim, but our path seems to grow brighter as we actually begin our journey. We cannot yet light the way to the end. However, we hope the suggestions of my government will be illuminating.

Let us keep in mind the exhortation of Abraham Lincoln, whose words, uttered at a moment of shattering national peril, form a complete text for our deliberation. I quote, paraphrasing slightly:

> We cannot escape history. We of this meeting will be remembered in spite of ourselves. No personal significance or insignificance can spare one or another of us. The fiery trial through which we are passing will light us down in honor or dishonor to the latest generation.
>
> We say we are for peace. The world will not forget that we say this. We know how to save peace The world knows that we do. We, even we here, hold the power and have the responsibility.
>
> We shall nobly save or meanly lose the last, best hope of earth. The way is plain, peaceful, generous, just—a way which, if followed, the world will forever applaud.

My thanks for your attention.

RUSSIAN PROPOSAL FOR THE CONTROL OF ATOMIC ENERGY [4]

The Commission for the Control of Atomic Energy, created in accordance with the decision of the Moscow Conference of the Foreign Ministers of the Three Powers and with the decision of the first session of the General Assembly, must proceed to the practical realization of the task set before it. The significance of these tasks and, consequently, of the activities of the Commission, are determined by the significance of the very discovery,

[4] By Andrei A. Gromyko, Soviet Delegate to the United Nations Atomic Energy Commission Speech at Commission's session of June 19, 1946. *New York Times*, p. 4. June 20, 1946.

and is doubtless only a foretaste of still greater conquests of science in this field in the future, and it emphasizes the great importance of the tasks of this Commission and therefore of the activities of this Commission.

As a result of developments in the last few years, circumstances have brought it about that one of the most important discoveries of humanity has found its application at the outset in a particular form of weapon, the atomic bomb. However, although, up to the present time, this use of atomic energy is the only known form for its practical application, it is the general opinion that humanity stands at the threshold of a wide application of atomic energy for peaceful purposes; for the good of the peoples as a means of raising their standards of welfare and their living conditions; for the good of and with a view to the development of science and culture.

There are thus two possible ways in which atomic discoveries can be used. One way is the use of these discoveries for the purposes of producing means of mass destruction. The other way is the use of this discovery for the welfare of humanity.

The paradox of the situation lies in the fact that it is the first way that has been studied most and most applied in practice. The second way has been studied and practically applied less. However, this circumstance does not diminish the importance of the tasks which lie ahead of the Atomic Commission, but, on the contrary, emphasizes still further in a high degree the meaning of these tasks from the point of view of the reinforcement of peace between the peoples. There can be no active and effective system of peace if the discovery relating to the ways of using atomic energy is not placed in the service of humanity and is not applied to peaceful purposes only. The use of such a discovery only for the purposes of raising the welfare of the peoples and widening of their scientific and cultural horizons will help to strengthen confidence between the countries and friendly relations between them.

On the other hand, if we continue to use these discoveries for the production of weapons of mass destruction, we may intensify mistrust between states and keep the peoples of the world in continual anxiety and mistrust. Such a position would work

against the aspirations of the peace-loving peoples who are thirsting for the establishment of a solid peace and who are making every effort to insure that their aspirations shall be transformed into reality.

As one of the first measures to be carried out, in order to carry out the decision of the General Assembly of the 24th of January, the Soviet delegation proposes a study of the question of the conclusion of international agreements forbidding the production and use of weapons based upon the use of atomic energy for the purposes of mass destruction. The purpose of such an agreement should be to forbid the production and use of atomic weapons, the destruction of existing stocks of atomic weapons and the punishment of all activities undertaken with a view to the violation of such agreements.

The elaboration and conclusion of such agreements would be, in the opinon of the Soviet delegation, only one of the primordial measures which must be taken to prevent the use of atomic energy to harm humanity. It should be followed by other measures designed to introduce means of assuring a strict supervision of the observance of undertakings entered into, the conclusion in connection with the above-mentioned agreements, the setting up of a system of supervision and control to see that the conventions and agreements are observed, and measures concerning sanctions against unlawful use of atomic energy.

The public opinion of the whole of the civilized world has already condemned the use in war of suffocating, poisonous and other similar gases, and the use of liquids and substances of the same character, as also bacteriological weapons, and have concluded agreements forbidding the use of such weapons. For this purpose the necessity of concluding agreement forbidding the production and use of atomic weapons is even more obvious.

Such a convention would correspond in a high degree also to the aspirations of the peoples of the whole world. The conclusion and elaboration of such an agreement and such a system of measures to insure the strict observance of the clauses of the agreements, the establishment of a system of control to see that the obligations contained in the agreements were observed and the establishment of sanctions against those who violate the

agreements, all this, in the opinion of the Soviet delegation, would constitute an important step in advance on the way of carrying out the tasks laid upon the Atomic Energy Commission.

It would also fully correspond to the aspirations and the dictates of common sense of the whole of progressive humanity. The need for its acceptance by states of the obligation not to produce or use atomic weapons is dictated also by the fact that the character of the atomic weapon is such that its application would mean untold misery to the whole of the peaceful population of the countries concerned.

The results of the use of this weapon are incompatible with the generally accepted rules, and the ideas reinforced by the common sense of humanity over a period of many centuries, regarding the rules for the conduct of war which lay down that innocent civilian population should not be destroyed. The situation, as it exists at the present time, created by the discovery of the means of applying atomic energy and the use of these means for the production of atomic weapons, excludes the possibility of normal scientific cooperation between the states of the world.

One of the fundamental elements of the existing situation is characterized by the absence of any kind of limit to the production and application of atomic weapons. These elements are important considerations, and only strengthen the suspicion existing between countries and worsen relations between them, calling forth political instability. It is clear that a continuation of this situation is likely to bring only negative results for the peace of the world.

Besides this, the continuation of the existing situation would mean that the most recent scientific attainments in this field could not constitute a basis for joint scientific efforts among the countries, directed toward the discovery and the perfection of methods of using atomic energy for peaceful purposes. From this there follows only one correct conclusion, namely, that it is indispensible that there should be an exchange of scientific information between countries and that it is indispensible that there should be joint scientific efforts directed toward a broadening of the possibilities of the use of atomic energy only in the interests of the raising of the material welfare of the people

and in the development of science and culture. The success of the work of this commission will be determined in a large measure by the extent to which it solves this important task.

The proposal for a wide exchange of scientific information is timely because it arises from the fact that such scientific discoveries as the discovery of methods of using atomic energy cannot remain for an indefinite time the property of any one country or any group of countries; inevitably, it becomes the property of many countries. This confirms the necessity of a wide exchange of scientific information upon the problem before us and the necessity of elaborating measures in this field, including organizational methods.

I have already stated . . . the general position as regards the task and character and the activities of the commission for the control of atomic energy. In the development of this general position, I would wish, upon the recommendation of my government, to lay before the commission two concrete proposals which in the opinon of the Soviet Government may constitute a basis for the adoption by the commission of a recommendation to the Security Council and thus play an important role in the task of strengthening the peace.

The proposals are as follows: The first one concerns the conclusion of an international agreement for the outlawing of the production and application of a weapon based upon the use of atomic energy for the purposes of mass destruction. The second concerns an organization of the work of the commission for the control of atomic energy. I will read the text of the first proposal.

Draft International Agreement to Forbid the Production and Use of Weapons Based upon the Use of Atomic Energy for the Purposes of Mass Destruction. (There follows after this a list of the signatory states, and the text continues:)

Deeply aware of the extreme importance of the great scientific discoveries connected with the splitting of the atom and with a view to the use of atomic energy for the purposes of raising the welfare and standard of life of the peoples of the world, and also for the development of culture and science for the good of humanity;

Unanimously desiring universal cooperation as wide as possible for the use of all people of scientific discoveries in the field of atomic energy, for the improvement of the conditions of the life of the peoples of the whole world, the raising of their standard of welfare and further progress of human culture;

Taking account clearly of the fact that the great scientific discoveries in the field of atomic energy contain a great danger first and foremost for the peaceful towns and civilian populations in case such a discovery were used as a means of applying an atomic weapon for the purposes of mass destruction;

Taking note also of the great importance of the fact that, through international agreements, the use in time of war of suffocating, poisonous and other similar gases and also similar liquids, substances and processes, and also bacteriological methods have already been outlawed by common accord between the civilized peoples; and

Considering that the international outlawry of the use of the atomic weapon for mass destruction would correspond in still greater measure to the aspirations and the conscience of the peoples of the whole world;

Animated by an intense desire to remove the threat of the use of these scientific discoveries for the harm of humanity and against the interests of humanity;

The high contracting parties decided to conclude an agreement to forbid the production and use of a weapon based upon the use of atomic energy, and for this purpose, appointed as their plenipotentiaries—(and here the list of plenipotentiaries will follow, whose credentials are found to be in due form)—agree as follows:

ARTICLE 1

The high contracting parties solemnly declare that they will forbid the production and use of a weapon based upon the use of atomic energy, and with this in view, take upon themselves the following obligations:

(a) Not to use, in any circumstances, an atomic weapon;

(b) To forbid the production and keeping of a weapon based upon the use of atomic energy;

(c) To destroy within a period of three months from the entry into force of this agreement all stocks of atomic energy weapons, whether in a finished or semi-finished condition.

ARTICLE 2

The high contracting parties declare that any violation of Article 1 of this agreement shall constitute a serious crime against humanity.

ARTICLE 3

The high contracting parties, within six months of the entry into force of the present agreement, shall pass legislation providing severe punishment for the violation of the terms of this agreement.

ARTICLE 4

The present agreement shall be of indefinite duration.

ARTICLE 5

The present agreement is open for signature of all states, whether or not they are members of the United Nations.

ARTICLE 6

The present agreement shall come into force after approval by the Security Council, and after ratification by half the signature states, including all states members of the United Nations, as under Article 23 of the Charter. The ratifications shall be placed for safekeeping in the hands of the Secretary-General of the United Nations.

ARTICLE 7

After the entry into force of the present agreement, it shall be an obligation upon all states, whether members or not of the United Nations.

ARTICLE 8

The present agreement, of which the Russian, Chinese, French, English and Spanish texts shall be authentic, is drawn

up in one copy and will be in the safe keeping of the Secretary-General of the United Nations. The Secretary-General shall communicate to all signatories a duly certified copy thereof.

I would like now to read the text of the second proposal. It concerns the organization of the work of the Commission for the control of atomic energy.

Basing ourselves upon the decision of the General Assembly of the 24th of January 1946, concerning the setting up of a commission for the study of problems connected with the discovery of atomic energy and other related questions, and in particular upon Article 5 of this decision, stating the terms of reference of the Commission, the Soviet delegation considers it necessary to make the following proposals concerning the plan of the organization of the work of the Commission for the initial period of its activity:

Part 1. The setting up of committees of the Commission, pursuing the aims indicated in the decision of the General Assembly to "proceed with the utmost dispatch and inquire into all phases of the problem and make such recommendations from time to time with respect to that as it finds possible."

In connection with this item, it seems quite necessary to establish two committees which, as auxiliary organs of the Commission, would be responsible for a general study of the problem of atomic energy and the elaboration of recommendations which the Commission might make for the carrying out of the decision of the General Assembly and other organs of the United Nations.

It is proposed that there should be set up two committees, the first a committee for the exchange of scientific information. This committee would be set up for the purpose of studying point (a) of Article 5 of the decision of the General Assembly of the 24th of January 1946. Among the tasks of this committee would be that of elaborating recommendations concerning practical measures for the organization of the exchange of information (1) concerning the contents of scientific discoveries connected with the splitting of the atom and other discoveries connected with the obtaining and use of atomic energy, and (2) concerning the technology and the organization of techno-

logical processes for obtaining and using atomic energy; (3) concerning the organization and method of industrial production of atomic energy and the use of such energy; (4) concerning forms, sources and the location of raw materials necessary for obtaining atomic energy.

I come now to the second proposed committee, whose task would be to prevent the use of atomic energy for the harm of humanity. This committee should be set up in order to attain the aims set forth in points (b), (c) and (d) of Article 5 of the decision of the General Assembly. The task of this committee would be to prepare recommendations on the following subjects:

1. The preparation of a draft international agreement for the outlawing of weapons based upon the use of atomic energy and forbidding the production and use of such weapons and all similar forms of weapons destined for mass destruction.

2. The elaboration and creation of methods to forbid the production of weapons based upon the use of atomic energy and to prevent the use of atomic weapons and all other similar weapons of mass destruction

3. Measures, systems and organization of control in the use of atomic energy to insure the observance of the conditions above mentioned in the international agreement for the outlawing of atomic weapons.

4. The elaboration of a system of sanctions for application against the unlawful use of atomic energy.

Part 2. The composition of the committees. Each committee would be composed of one representative of each state represented in the Commission. Each representative may have advisers.

Part 3. Rules of procedure of the committees. The rules of procedure of committees shall be drawn up by the Commission.

Like the proposal for the conclusion of the agreement, these proposals which concern the organization of the work of the Commission are a practical means of advancing at the present time. The convention would be a concrete and important step forward in the direction of setting up an effective system of con-

trol of atomic energy. This measure would have an immense moral and political significance, and might strengthen the political stability in the world and the friendly relations between the peoples.

The creation of the two committees that I have proposed with the tasks as I define them, would mean the adoption of a concrete plan of work of the Commission in the initial stages of its activities and would at the same time mean the adoption of the necessary organizational forms for the carrying out of its work which would enable it to proceed quickly in the proposals of the broad exchange of scientific information and on questions related to the prevention of the use of atomic energy for the harm of humanity.

The activity of the Commission for the control of atomic energy can lead to the desired result only if it is in full conformity with the principles of the Charter of the United Nations, which are at the basis of the activity of the Security Council because the Commission is an organ of this organization, working under the direction of the Security Council.

Efforts made to undermine the activity of the Security Council, including efforts directed to undermine the unanimity of the members of the Security Council, upon questions of substance are incompatible with the interests of the United Nations created by the international organization for the preservation of peace and security. Such attempts should be resisted. I considered it necessary to make this statement in order that from the very beginning of the work of our Commission I might make clear the position of the Soviet Government as regards the question of the character and basis of the work of the Commission upon the question of the preparation of its recommendations as regards measures of control of atomic energy placed before the Security Council.

In conclusion, I wish to say that in this statement I aimed chiefly at underlining the extreme importance to be attributed to the conclusion of the above-mentioned agreement for the outlawry of the production and use of atomic weapons. The conclusion of such an agreement would constitute an important practical step in the direction of fulfilling the task which lies before the Commission.

THE INTERNATIONAL CONTROL OF ATOMIC ENERGY [5]

You may think it odd that I should be dealing with a problem of statecraft. For that I have two apologies One is that I had the privilege of working on these questions with a board of consultants to the State Department. The five of us had rather different backgrounds; and although we felt we were not qualified to discuss many of the more finely diplomatic aspects, the agreement that we reached, the intercourse and interchange of ideas that went into writing our report, gives me some confidence that the views I am presenting are not purely personal views. For another thing, it may be permitted that men who have no qualifications in statecraft concern themselves with the control of atomic energy. For I think that the control of atomic energy is important, in part, because it enables us to get away from patterns of diplomacy which are, in some respects at least, unsatisfactory as a model for the relations between nations, and to set up instead a working relationship between the peoples of different countries, which has in it some promise for the future.

I don't need to review the arguments for seeking international control: the appalling and revolutionary character of the weapon, the inadequacy of military defenses, the impossibility of any permanent monopoly which might protect us—every American knows that if there is a third world war, this country will be wounded, maybe fatally wounded, will in any case come through it with nothing like the freedom from injury which we have had in the last two. Every American knows that if there is another major war, atomic weapons will be used, and that the problem we are dealing with is the problem of the elimination of war. We know this because in the last war, the two nations which we like to think are the most enlightened and humane in the world—Great Britain and the United States—used atomic weapons against an enemy which was essentially defeated. Under these conditions it is not thinkable that in any

[5] By J. Robert Oppenheimer, University of California; formerly Director of Los Alamos Laboratory; co-author of the Acheson Report. Condensation of lecture at Cornell University. *Bulletin of the Atomic Scientists.* 1:1-5. June 1, 1946.

future major conflict, where the very life of a nation may be at stake, these weapons will not be used—they are much too effective for that.

This is an important thing to keep in mind, because it shows that we must ask, of any proposals for the control of atomic energy, what part they can play in reducing the probability of war. Proposals which in no way advance the general problem of the avoidance of war, are not satisfactory proposals.

The threat of atomic warfare and the rivalries for raw materials, for industrial capacity, for power plants, for technical know-how, for scientific experience, which are inherent in any struggle to maintain superiority in the field of atomic weapons, must not be allowed to persist and be in themselves a source of war. If you think of the dangerous situations which have arisen in the world because of the struggle for raw materials, far less critical than uranium, for oil, for instance, you will see what sort of thing I have in mind.

One may say, since the problem is the avoidance of war, why do you not attack it more broadly and more generally? Why not start right away on some of the things that we know might lessen the danger of outbreak of war? What are they? Well, I don't know, but I think when people say if we had universal disarmament, that is, if national armaments were forbidden, this would reduce the chance of war, they have something. When people say, if we had a world government, and if, on matters affecting the common security, the sovereignty of the nations was limited, they have something. And I think when people say that if we could provide for all peoples in the world a rising standard of living, and better education, and more contact with one another, better understanding of each other, and equal access to the technical and raw materials which are needed for improving the standard of living, they have something. It is not my intention to argue that these things should not be done; that would be quite wrong They must be done. But I think that no one could have looked at the history of the world without being aware of the fact that progress in these fields is rather slow, and is likely to be very slow. I therefore wish to stress the fact that in the field of atomic energy,

certain of the difficulties which exist in other areas, are absent; and wish to suggest that in addition to a general effort all along the line, a specific effort focused on this one problem may have a very useful part.

Now, what are the specific points about atomic energy? The main one is that one *can* set up a system of control. When I use the word *can*, I mean it is consistent with the technical facts, it is consistent with the way ordinary people behave, it will work in a human sense and a technical sense. One reason for this is that it is a subject of the most extraordinary common concern. I know of nothing which is of as little to the advantage of any men anywhere as that atomic warfare should break out; I know of nothing which is as sure to bring ruin to all as that atomic warfare should break out. I know that in the exploitation of the constructive uses of atomic energy there is a diffuse, and at the moment not clearly defined, but sure benefit for all peoples. And I think that the overriding importance in this field of those interests which the various nations have in common, and the relatively secondary importance, although not negligible, of the separate national interests, is one of the points which makes this a field to make progress in. Another one is that it is a field that has not been limited in the freedom of action by centuries of tradition. It is a new field, and with the exception of the United States, it is a field of which it may be safe to assume that not a terrible lot of progress has been made elsewhere; it is a field in which what you do now is not as much an eradication of past patterns as the building of new ones.

If we ask, what are the methods by which one might control atomic energy, one finds a rather surprisingly small number of ideas. I think no one would seriously argue that the world is such today that a convention saying, "we will not make atomic weapons," would have much value. This is a sad fact; it rests upon the lack of community, the lack of fraternity between various peoples, and the terrible strain which suspicion and fear will put on such convention. We know very well what we would do if we sign such a convention—we would not make atomic weapons, at least not to start with, but we would start out and build enormous plants, and we would call them power

plants—maybe they would produce power; and these plants we would design in such a way that they could be converted with the maximum ease and the minimum time delay to the production of atomic weapons, and we would say, this is just in case somebody two-times us; and we would stock-pile uranium, we would keep as many of our developments secret as possible, we would locate our plants, not where they would do the most good for the production of power, but where they would do the most good for protection against enemy attack. We would do that, and it is reasonable to believe that all other nations would do it, and with the secrecy which inevitably surrounds such undertakings, suspicions would be very hard to resist. A system of that kind is sure to collapse as international tensions grow—and they are sure to grow in one time and another. So people have thought of methods of reinforcing such conventions, and I have heard of three such methods, of which I wish to disparage two, not as wrong, but as inadequate, and of which I wish to speak up for one.

The two control methods that I wish to disparage one may call the *regulatory,* and the *retaliatory* methods. By *regulatory approach,* I mean the following: you may say, all right, let us sign this convention; we don't trust one another, and therefore the next step is to set up a system of control, whereby we can find out whether these conventions are really being observed. This is usually called inspection, and the idea would be this—that you leave in the hands of nations, or of nationals, as the custom of the country may be, the development of atomic energy, the production of power, research activities, the manufacture of fissionable materials. You super-impose on this national development, a super-national agency, a corps of refined policemen, whose job it is to go around and see that nothing is happening that is contrary to convention There are really two points to this: first, you must see that no enterprises are being carried out which are not allowed, and second, you must see that the allowed ones are really doing what they say they are doing, and not doing something wicked on the sly. There is a great need for such regulation, and any system of international control will have some of it. But I, and the group I worked

with, felt completely desperate about the attempt to build this cops-and-robbers scheme into anything really effective, because it seemed to us the robbers always have the advantage and the cops are always dumb cops. It is true that you can't mine uranium in the back yard, but there are lots of places you can mine it, and even the detection of uranium mining might be a difficult thing for an outfit which had no other purpose than detecting illegal activities. There is very much more than one way of going from the raw material to the bomb that we know of, perhaps four or five that work today, and we are quite sure that new ones will be discovered. I'm afraid the cops could never know about the new ones, only the robbers. The national rivalries which are permitted to exist under these conditions, will cause every nation to come as close to evasion as they can, and instead of having a situation in which it is to the advantage of the operators to do things safely, you will have it to the advantage of the operators to cut corners just as much as possible, because the operators are concerned with their own national advantage. You see a great plant that is going up, and you were assured that this plant has as its purpose only the production of power for this poor town that has never had enough, and you look at the records and it looks to you as though there were plenty of power there, and you have to begin worrying about what the real purpose of the people who are building this plant is, and purpose is a hard thing to establish. It's very hard to tell whether a man is mining uranium because he is interested in cancer or interested in war.

We came to the conclusion, not that one could survive *without* such regulation, but that such regulation must be reduced, and that one must make arrangements for converting the regulatory agency into a research agency, a development agency, a constructively operating agency, if it was to have the people, the know-how, the skill, the progressiveness, and, in a general way, the power, to find out enough even to know what it was looking for. And that is a quite different thing from national operation on which an international supervision or inspection has been superimposed.

Now, the *retaliatory approach* may also have something in it; but I think it hasn't in the form in which it is usually proposed, that is the following: let us make a certain number of bombs, 100, 250, and let us give them to an international agency, then this international agency will be able to punish any state which starts atomic warfare, or which even looks as though it were going to start atomic warfare. It would be an easy thing to prevent war if you could be sure that whenever any national action were contrary to the general interests, all other nations would gang up and stop it. But experience shows that this tends not to be true, that very broad cleavages occur, differences of opinion, vacillations, and that you do not have that effective operating unity which enables you to put your finger on the transgressor.

Then, I think that atomic weapons are singularly unsuited as police weapons—they are much too much weapons of total war. And in the third place, you may say about bombs that they are international, and may paint them with the colors of the United Nations, but you have to put them somewhere, and if you put them somewhere they are capable of being seized. Now any international control scheme is in some respects an invitation to seizure, but this one is an invitation to seizure which pays off in aggression immediately—there is no delay between the time you seize the bombs and the time when you can do damage with them. This temptation, in times of international trouble, would be just one of the things that is most likely to set off a conflict.

We said: let us take the fact that this is a field in which useful things can be done, but are hard to do; let us create an international organization responsible for developing atomic energy, for getting what good there is out of it, and in the same time for protecting the world against its destructive uses This is an easy thing to say, but what does it mean? It means that all those critical activities which are or may be essential for going from the mine to the weapon, are not to be conducted by nations or by nationals—they are not even to be conducted under license by a company or a national atomic energy commission. Things like the mining of uranium, which is a unique,

indispensable raw material, are to be done by an international authority; things like the building of power plants, which make fissionable materials or which may make fissionable materials, things like the separation of isotopes to get explosive materials, these are jobs which are too easily diverted, too trigger-happy to be left in national hands. This means that one would regard the mining of uranium by a national operator as a violation of the convention—you wouldn't have to ask whether this mining is being conducted for a legal or an illegal purpose—the fact of the mining would be illegal. This means that the construction of a primary plant, a primary reactor to make plutonium, and to make power at the same time, would be an illegal activity for a nation; this means that research on atomic explosives, which I think must be undertaken, because unless you know what the possibilities are, you will not be prepared to prevent their realization, would be an illegal activity for a nation or for nationals —it would be legal only if conducted by an international organization, which we called "The Atomic Development Authority" in order to suggest at least two important aspects of its function —it must have very wide authorities, and it must really make for development.

Now, let me go over it again. The Atomic Development Authority would be responsible for *mining uranium and thorium*; this is a matter which requires a great deal of detailed study, because we don't know enough about the geological distribution, we don't know what the possibilities are of working low-grade deposits—deposits under about a per cent are normally not taken seriously. These are problems of development and research; we want them to be undertaken internationally, so that the body which is trying to protect the world, will know more about the dangers and about the possibilities than all the other people in the world. You never get experience in mining uranium by sitting at a desk talking about how other people are mining it—you've got to get into the field and get your hands dirty. This would mean that the Atomic Development Authority would be in the position to say, let's not mine the uranium here, because it's too hard to prevent diversion, let's not worry about this mine, because in it the by-product uranium

doesn't amount to enough to be a danger, but in this mine, the by-product uranium is so important, that we've got to have really close control, even though the mine claims to be, in large part, a mine which is putting out vanadium.

At present, there are no power plants, and the first thing the Authority would have to do is find out how to make them. This I think, will be a matter of years, not decades The authority would then start building such plants, taking into account the following factors· first, where is power needed; second, how can we do this in such a way that in no one political sphere of influence in the world, in no one nation, is there a preponderance of these plants, which, if seized and diverted, can in time make atomic explosives. How can we make these plants so that their seizure and diversion is as little profitable as possible, so that the time needed to convert to the manufacture of explosives is as long as possible? These are then some of the questions: the economics of the power, sociology of the power, strategic balance to make diversion and seizure an unprofitable business, safe design. These are things that you cannot do by regulation; you can only do them by operation.

As far as *research* is concerned, most of this has no essential danger in it. At least, it is not my view that knowledge is the source of danger; the source of danger is weapons. Therefore, it was our hope that the Authority would conduct its own investigations, but would in no sense attempt to have a monopoly, even on those investigations which bear directly on the release of atomic energy There is only one field in which we felt it desirable that there be a monopoly in research, and that is with atomic explosives, and I think the reason for that is obvious —there is no reason why a nation should explore this if it does not wish to use it. There is reason why the international organization should explore this, because it has the responsibility for seeing that no one does this, and unless it knows what the "this" is, and can define it, it can't see to that.

We were aware that in setting up a monopoly, which might in the course of twenty years produce a very substantial part of the power of the world, and which would be very important to the economy and life of the nations, had some dangers, and

this we thought we could meet in the following way: Many of the constructive uses, which have to do with making tracers, operating small reactors for research purposes, using radiation to study changes of biological and chemical systems, are not intrinsically dangerous. You can set the reactors up so that they do not make enough fissionable material to be significant from the point of view of atomic weapons. You can set them up so that the material contained in them is (a) not enough to make atomic weapons, and (b) not very useful for that purpose, —being in such a state that you've got to doctor it in a rather long process, before it can be used for bombs.

Another thing one can build power plants, instead of producing additional plutonium, or other fissionable material, burn it up, and a plant of that kind is in many ways very much easier to inspect, because if any one diverts any of the material, the plant has to shut down, and this is a rather easy thing to notice. It can be designed in such a way, that you can't smuggle uranium or thorium into it, and convert them into fissionable material, without that being observable to the most casual inspector You can use in such plants active materials which are as unsuitable and as difficult and as inefficient for making of atomic explosives as possible, and therefore reduce the temptation to seizure.

These then, we thought, were the kind of developments which could and should be left to national or private exploitation: research, of course, whether it bears on radiations, or on power, or on atomic energy, or on anything else but atomic explosives; the use of tracers, the industrial and medical use of radiations, and the power plants which are, by the material in them, and by their design, and by the fact that they are destroying rather than creating explosive material, rather easy to inspect —not so that you can forget to watch them, but so that the watching is a fairly straightforward task. We thought that it would be a great advantage if these things were left free for competition, under a system of licensing and inspection, because this will lead to an intercourse and a connection between the technical people of the international authority and the technical people who are not part of it. This will produce several

benefits: In the first place, if you have a total monopoly, you are always in danger that something will go sour with the organization, and the people will become second-rate, they will get to be friends with each other, and will no longer be exposed to the necessary criticism. In the second place, if you have no organic relation with national undertakings, you will have a much harder time finding out whether they have any dangerous tendency or not. If you are working in a national laboratory, trying to show people how to use a reactor, and also watching so that nothing wrong be done with this reactor, in the dual role, that is, of a helper and an inspector, you're going to pick up the gossip of that laboratory, you're going to be free to pass on the gossip of your own outfit, and there is probably no better way of really having cognizance of what is going on.

This does not in any way eliminate the need for inspection. What I have tried to indicate is that it simplifies the problem enormously, because you have valid points of contact with national industry, because you are looking, not for a purpose behind an operation, but for the existence of an operation; because you are not a man who is trying to keep up with someone who is running much faster than you can, but the top guy, who knows as much or more than is known to any other group, because it is your job to know it.

This, then, is the pattern we had in mind: *The setting up of a genuinely International Development Authority, entrusted with the dual function of rapidly developing the beneficial uses of atomic energy, and of being responsible for preventing its abuse; the licensing of activities which would not make for national rivalry, which do not lend themselves to the making of weapons, but which are technically closely enough connected with the atomic energy problem, so that by their licensing one would have established a living relationship between national and international experts.*

Now the questions of what this Authority might look like, how it is set up, what sort of procedures it has got to follow—those are extremely complicated, and there are two kinds of considerations, involved in the process of arriving at agreement on them. One has to distinguish very clearly between considera-

tions which are essential for the *workability* of the plan of international control, and those which may make this plan *acceptable* to one nation or another. There are many problems we must explore, but I think it is meaningless, at the present time, to lay down a schedule which would fully protect the United States and be ideally suited to the securing of our own national interest, because this is the job which the U.N. Commission must undertake. The Commission must attempt to find some workable compromise between the conflicting national interests. In doing so it must come back again to the fact that, although these interests do conflict, these conflicts are trivial compared to the overwhelming common interest in getting the security we are after.

What kind of security is it? It is not the elimination of war, and, as we have said, if war breaks out, you'll have atomic bombs. It is a guarantee that at a given time there are no atomic bombs, that no nation is either mining uranium or processing fissionable material, or manufacturing bombs, or set up to do any of these things. If this plan works, the first step which would have to be taken by a nation bent on aggression is either the seizure of the facilities belonging to the Authority or the violation of the convention by which the nations agreed not to build certain kinds of plants, not to mine certain ores. Now this *may* happen—but I don't think it will, because the nation doing it will be coming out and saying, "We're going to make atomic war," and gives you a clear warning. Now the time might not be very long; it may be a year, maybe somewhat longer, conceivably even somewhat shorter, before the seized facilities or the new facilities which a nation can build, will make major atomic warfare possible. But the violator will have raised the brightest red flag he can, and every other country will know that they are in for it. Now this is, I think, about as much as you can expect if you want to use retaliation as a method of preventing atomic warfare. You can insist that the danger signal flashes early enough and that it be clear enough, so that there can be no mistaking the fact and purpose of a violation.

Now, that is one advantage. The other is that the Authority can really get ahead with the uses of atomic energy. I

don't regard this as the thing that, in itself, would be worth all the fuss, but the point I have tried to make, is, that if you don't try to develop atomic energy, you can't control it—you can't say first we will control it, and then we will develop it, because the developmental functions are an essential part of the mechanism for control.

Third, the plan will bring together, in a constructive, collaborative effort, men of various nations, on a job of vital interest to the maintenance of peace, and the furtherance of human welfare. This is something rather new, you will get, not only ambassadors, but chemists and physicists, and business men and engineers, working together with a purpose which is completely common, and in which they will find out how to overcome their national differences, because there is nothing in the set-up which exacerbates their national differences It is a scheme in which the extreme nationalism, which we all feel to be the true poison of today in the world, will have no place, and in which the sense of fraternity and common understanding will have a chance to get some place.

It will do more than this, because by removing from the world the fear which you don't know today, but which five years from now, eight years from now, you would otherwise know in the most terrible form, the fear that any day now, an attack may be coming, it will remove one of the most frightful causes of war itself. Mark my words, *if there is no international control of atomic energy, the next war would be fought to prevent an atomic war, but it will not be successful.* It will do more than this, because once you have started a program like this, it becomes a natural for many other problems. I don't know very much about bacteriological warfare, but it is clear that the purpose of it is to infect the enemy and not infect yourself, and it is clear that even more than atomic energy, it rests on secrecy—plans of this kind simply cannot be carried out if the enemy knows what you're going to do—he will take the same steps to protect himself that you are taking to protect your own population. And it is also clear that in the field of bacteriology and immunology, generally, there are constructive aspects I don't see any reason why, once a plan of this kind has been tried and

works, problems of health, of immunology, cannot be internationalized, too I think that this would have many advantages, from a technical point of view, and would almost completely eliminate the threat of bacteriological warfare.

Another point—we all know how acute rivalry for raw materials has been, and what a part it has played among the causes of past wars. It was so recognized in every declaration this country has ever made about access to raw materials. Well, I think if one can solve the problem of uranium one can solve the problem of oil, and I think that here again there is a healthy pattern for extension. And I would go a little bit further and say, if you have managed to have a working arrangement whereby you forego the worst of all arms, the most effective of all arms, the one you would want to use first in surprise, you have made a big breach in the problem of disarmament, and it should not be quite so hard, once that has been done, to generalize disarmament to other weapons of mass destruction, and, in fact, to other weapons of war.

Now, you may ask, what is going to happen now? Well, there will be a meeting of the United Nations Atomic Energy Commission, which is a sort of Security Council with its cap on sideways, but which is attended by certain scientific advisors. Presumably, the ideas that people have had about inspection, about retaliation, about development, about the A.D.A., will all be aired, and I hope they will be very thoroughly aired. And if there is any agreement on what we are heading for, then there will be much discussion about how to get there, what to do about raw materials, how to get started, when to stop making bombs, what to do with the bombs we have, what sort of accounting do we want, when do we reveal what we know about nuclear physics, or about metallurgy, and so on. These are very tough problems, and it's going to be a terrible game of poker, but if you keep in mind that the poker aspects of it are secondary, that the main thing is to get agreement on a system that will provide security, then I think it looks, not cheerful,—and I should not want to have said anything that sounded cheerful,—but so worth trying, that one cannot fail to get into it.

If, as a result of these discussions, there is something to agree on, it will have to be worked into a treaty or charter, because, the United Nations Commission has no power—it is only empowered to study, and its power to study is limited by our willingness to make information available—ours as well as of all other nations. Any delegate can say, "I can't say any more, my government orders me not to," or "I can't make any more concessions, and I might as well go home." It is a study group; but if this study group manages to produce a document, that document will call for an entirely new kind of international outfit, an Atomic Development Authority, and that authority, once constituted, will have nothing in it corresponding to the veto power in the Security Council; it will be an outfit which may not have the power to compel compliance, but which will know the difference between compliance and noncompliance. The failure of any major nation or any nation which plays a key part in atomic energy to join, will mean the scheme doesn't work; if any nation walks out, the scheme is dead; but as long as it lasts, it will be an international authority different from anything we have in the world today; its law will be superior to the law of the land—it will be enforced by the law of the land; and it will be an organization in which people of different countries will work together, forgetting what countries they came from, because they've got a common job to do—not forgetting entirely, just as one doesn't forget that one is from Georgia, but forgetting when it gets in the way.

The putting of such a plan into effect will require ratification, and if the United States accepts it, it is going to give up certain advantages which we possess today—which we are sure we would lose anyway, but which we will be scheduling to lose probably faster, than we would otherwise lose them. We are going to give these advantages up, and we are going to make it a crime for an American to mine uranium or for the government of the United States to mine uranium, we are going to make it a crime for an American or the government of the United States to process plutonium; we are going to leave these things, as are all other nations, to an outfit which has the security of the world at heart.

It is quite clear that this is a long road. I have the feeling that we have come something of a road already, but it is also quite

clear that to teach the end, will call for a spirit rather different from that that has animated most international discussion, in which the separate national interests have been the overwhelming consideration.

HOW TO CONTROL THE ATOMIC THREAT[6]

The world-shaking discovery of atomic power, the greatest since the discovery of fire, can have only one of two end-results: either the unparalleled shattering of our civilization through atomic blasts, or an unparalleled era of peaceful science and mass happiness. Because of the Industrial and Atomic revolutions, one of two solutions of the problem of lasting peace has become entirely possible for the first time in history: either the conquest of the ruins of the world by a world dictator; or the conquest of ruinous wars by an effective organization of peaceful peoples.

Today, and during a few short years, it lies in the power of the English-speaking democracies, in cooperation with other peaceful nations, to determine which of these two patterns will shape the present and future history of humanity. The pattern of lasting peace will depend entirely on the capacity of the United Nations leadership to devise and firmly to establish now a world collective front against any aggressor, based on the permanent and effective control of atomic and heavy arms.

The natural scientists have unlocked the eternal secret of atomic structure. It remains now for the social scientists to create a new social structure, lest the atom destroy man.

1. The Basic Cause of War. Whenever there is no adequate central authority to protect the many against the violence of the few—be they individuals, groups or nations—aggression is inevitable. In the family of nations today, there is no adequate central authority. The government of each state is a law unto itself, free to rearm or attack as it deems fit. The basic cause of aggressive wars, therefore, is the age-old anarchy of sovereign states and the lack of an adequate central authority. . . .

[6] By Ely Culbertson, Bridge Authority; Author of *Total Peace* and other works. 13p. Total Peace, Inc. 16A E. 62d St. New York. 1946.

It will be shown later that there is overwhelming scientific evidence that, by use of modern methods, wars of aggression can be eliminated, even though this was impossible in the past. It may be excusable for an ignorant politician or a narrow-minded military man to rush in where a more careful thinker fears to tread. But this basic assumption of the "inevitability" of war explains the gangrene of moral defeatism that pervades so many of our intellectuals, editors and statesmen, causing them to flounder in shallow waters, seeking all sorts of ersatz solutions, rather than grapple with the central problem of the anarchy of sovereign states. The least one can ask of them before they choose to advise the American people, is to suspend their judgment until with fresh and open minds they reexamine the question of whether wars of aggression are really inevitable. For on the answer to this question now depends not only the immediate policy of the United States, but probably the very survival of civilization.

2. *The Causes of Our Era of Total Wars.* Even before the atomic discovery, humanity found itself in an unparalleled era of total wars and turmoil. The general cause was the breakdown of the ten-thousand-year-old pattern of the agricultural civilization, brought about by the Industrial Revolution. The specific cause lay in the revolution in communications and in the nature of military weapons. As a result of scientific discoveries, we have entered the age of gigantic, intricate fighting machines—armored ships of land, sea and air. To produce these heavy arms it is necessary to utilize the resources of entire continents and the man-power of scores of millions.

3. *The New Atomic Arms.* The atomic bomb and other atomic weapons yet to come are the culmination of this revolution in the destructiveness of scientific weapons. We must guard against three deadly fallacies in connection with the emergence of atomic arms:

A. It is naive to assume that the utter destructiveness of atomic arms will bring humans to their senses and automatically inaugurate a new era of lasting peace. We cannot entrust the future of the world to the childish assumption that a clique of greedy or ideological fanatics in control of a government will

voluntarily abstain from using atomic bombs. History shows that conquerors and fanatics, when in possession of new destructive weapons, have been far more encouraged by their chances of success than deterred by the horrors of war. And the very nature of atomic weapons makes it possible for a clique in control of a government to destroy overnight by a stealthy attack the vital centers of nations thousands of miles away.

B. Some authorities advocate the establishment of worldwide democracy, or removal of the economic causes of war, or education to change the hearts of men, as the best means to insure protection against the atomic threat. All of these will help greatly But so long as men in control of any government can rearm with impunity or attack a divided world with chances of success, just that long will there be wars of aggression. And just that long will the cloud of the atomic bomb hang over every home in the world.

Before the age of the atomic bomb, there was time for the economists, the educator and the minister to carry out the gradual and gentle improvement of the world. Today their work will be in vain unless we first remove the terrifying threat of atomic weapons Prime Minister Attlee said very truly: "Unless the forces of destruction now let loose are brought under control, then it is vain to plan for the future."

C. There are many others who hold to the fallacy that as a result of atomic bombs other fighting machines and mass armed forces have become obsolete This may be true in a generation or two, when the dawning atomic revolution may replace our industrial revolution. Until then atomic arms, however devastating, are but a part of the complex modern war machine.

If another war comes, it will be fought with atomic weapons and other fighting machines. Plants will be dispersed and nations will burrow underground. Atomic bombs will be much too scarce to destroy the thousands of isolated targets which it will be necessary to destroy if the will of a desperate enemy is to be broken. And even though the depredation of atomic weapons will be enormous, vast masses of trained men equipped with tanks and guns and protected with air and sea fleets will have to move, sooner or later, into the enemy's territory so as to deprive him of his means of production and use of atomic weapons.

It follows that an effective international control of atomic weapons will not be possible in the foreseeable future without a corresponding international control of heavy fighting machines. Atomic and heavy arms are mutually dependent, and control of one necessarily implies control of the other.

4. *The Time Factor*. Today the United States is the mightiest nation of all time. But this immense power is temporary. The same Industrial Revolution that made the United States the greatest producer of heavy fighting machines and the initiator of the atomic revolution is rapidly industrializing other nations with overwhelming manpower and greater resources. Under the present tempo of industrialization, Russia, which is already the second largest industrial nation, is rapidly approaching America's productive capacity and will inevitably surpass it. This does not mean that Russia will in fifteen years equal America's know-how in every industrial field. But even an incompletely industrialized Russia will outproduce the United States in fighting machines, creating in the heartland of Eurasia an impregnable bastion of scientific weapons. The reasons are Russia's greater manpower and resources, ruthless totalitarian regime, and far superior strategic position in the heart of the Eurasian continent, with a power vacuum in Europe, the Middle East and the Far East. Behind Russia there loom other vast, hitherto dormant nations which are also becoming rapidly industrialized and will soon learn how to make fighting machines.

The time of decisive superiority given to the Anglo-Americans by the atomic revolution is far shorter. True, even when other states produce atomic arms, we will still retain a lead in the production of atomic weapons and the indispensable raw materials. But this lead will be ephemeral. Even now Soviet Russia, with her satellite states and half of Germany, is undoubtedly making a gigantic effort to catch up with us and surpass us. Not only Russia—but France, China and all other states will strive desperately to acquire the most precious weapon of history.

Thus history has imposed upon the United States a fateful time table. The maximum limit of this time table is less than

twenty years for industrial supremacy, and probably only a few years for atomic superiority. As Winston Churchill stated:

> So far as we know, there are perhaps three or four years before the great progress in the United States can be overtaken. In these three years, we must remold the relationships of all men of all nations in such a way that these men do not wish, or dare, to fall upon each other for the sake of vulgar, outdated ambition or for passionate differences in ideologies, and that international bodies by supreme authority may give peace on earth and justice among men. . . . From the least to the greatest, all must strive to be worthy of these supreme opportunities. There is not an hour to be wasted; there is not a day to be lost.

A system for international control of scientific weapons must be both effective and acceptable. To be effective, it must be based, not on mere promises of governments of sovereign states, but on a common, organized authority with power to carry out and enforce these promises. At the same time, a system must be politically acceptable to a substantial majority of the American people and to most of the other states.

The minimum requirements for an effective system are:

A. A central authority must be established in which all states, large and small, are fairly represented, and which acts by a simple majority vote (no veto right).

B. This central authority must have at least two powers delegated by the member states, one dealing with the production of atomic and heavy weapons (prevention of aggression), and the other power dealing with the use of these or other weapons (defense against aggression).

C. To support these two delegated powers, the central authority must have at its direct disposal an adequate armed force independent of the power politics of member states.

The minimum requirements for an acceptable system are:

A. The sovereignty of all member states must be preserved, except for the right of unrestricted production of atomic and heavy arms, and the right to wage aggressive war.

B. Each state must retain its ability to defend itself with its own national armed forces and armaments. This includes the right to maintain by friendly arrangement leased bases outside its

own territory for the sole purpose of strategic defense, not spheres of influence In the case of the United States, this specifically means a strategic zone from Iceland to Thailand, including some of the former Japanese bases in Indo-China, Thailand, and the Netherlands East Indies. As a result of the atomic revolution it is indispensable that our strategic zone be anchored on the Asiatic mainland, rather than ending nowhere, in the Pacific islands. For it may be necessary for American land forces to move in quickly against some Asiatic dictator. The duration of these leased bases is the time necessary to establish and test in actual operation the international organization for control of scientific weapons and for collective defense.

C. In view of previous commitments, the United Nations Charter must not be abandoned, but extended or improved, wherever feasible, to meet the new atomic threat.

D. In the special case of atomic arms, the United States, Britain and Canada must retain the right to preserve their existing superiority in the production of atomic weapons until the United Nations Organization is adequately strengthened. After that, all information will be mutually exchangeable among member states.

Even before the atomic bomb, the terrifying power of fighting machines had pushed humanity to the edge of the abyss. Most of the social engineers were running around like squirrels in a cage, some with economic cure-alls, some with visions of a United States of the world, some with the bullet-ridden Covenant of the League of Nations, and some, fancying themselves as power politicians, with an amateurish revival of the Holy Alliance. Can any of their "solutions" meet the atomic threat?

There are two historical types of international organization—the federal type (such as our Federal Union) and the league type (such as the United Nations Charter). The federal type has the necessary requirements to make it effective; but it requires drastic limitation of sovereignty and therefore is unacceptable. The league type, on the other hand, has the minimum requirements to make it acceptable; but it has none of the essential requirements to make it effective The United Nations Charter is admittedly only a beginning. But its present structure makes it absolutely impossible to prevent any major power from piling up, secretly

or openly, all kinds of atomic and heavy arms or engaging in aggressive war. In fact, the right reserved for any of the Big Five to veto any decision of the World Security Council dealing with preparation for or waging aggressive war, even when the vetoing state itself is the aggressor, encourages rather than discourages an atomic armament race and aggression.

The third "solution" is permanently to entrust the United States, Britain and Russia with the world monopoly of control and regulation of atomic arms. In the first place, this is unacceptable because, as President Truman stated, the Anglo-Americans have no intention of giving up to Russia their atomic secrets. Even when Russia achieves her own production of atomic arms, this proposal will still be ineffective because it does not take into account the probability that the Big Three may seriously disagree among themselves or engage in a disastrous atomic armament race. It is pure faith-healing. Paper agreements among the governments of the Big Three or the Big Five are not enough. Their word may be as good as gold. It never has been as good as steel. For the United States to fritter away its enormous present superiority and to base its whole destiny on the mere assumption that great powers will lastingly cooperate in the future, would be political folly without parallel in world history.

The fourth proposal is to utilize the present enormous superiority in atomic and heavy arms of the Anglo-Americans to establish, by force if need be, a Pax Anglo-Americana with rigid worldwide control of atomic weapons. If there were no other way out, this would be the most logical solution. But it would also be the most tragic solution. A world co-dominion by the United States and Britain could be achieved only at the price of a catastrophic war against Soviet Russia, with the probable destruction of democracy within the United States and Britain. We would dissipate our creative energies keeping the lid on a conquered world, instead of helping the world to build in freedom a new, undreamt-of civilization. Nor it is likely that the American people could be induced to wage a preventive war against Russia during the next three years, which is the critical time during which Russia will be relatively weak.

Thus, we cannot solve modern problems of atomic engines of destruction by antiquated methods. We must usher in, together with the age of atomic energy, the age of organized law to terminate the anarchy of sovereign states. This can be done, and done now, by means of the Quota Force plan.

The Quota Force plan proposes the immediate reorganization of the United Nations Organization so as to make possible the permanent limitation and control of scientific weapons (atomic and heavy) and guaranteed mutual defense of member states against armed aggression. This immediate reorganization is justified on the grounds of the Atomic Revolution, and can be carried out by means of basic amendments to the United Nations Charter, offered by the government of the United States. If within a time limit of ninety days the basic amendments are not adopted, then the United States can make use of an alternative method for worldwide adoption of the Quota Force plan This alternative method (always assuming that the amendments-method is rejected or delayed) is called the Federative Alliance. It can operate within the United Nations Charter as a simple regional arrangement.

The Federative Alliance is a new limited federation, implemented by a federative authority, or government, with limited, delegated powers. The Federative Alliance will be offered by the United States simultaneously to Britain, France, Russia and China. When any one (or more) of them accepts and subscribes to the basic treaty, the Federative Alliance is established. The major states which do not accept may join the Federative Alliance later at any time If they do not join, they may not be threatened or coerced. When established, the Federative Alliance is automatically open to all the lesser states.

The basic amendments to the United Nations Charter proposed by the United States will incorporate the following provisions, to which all member-states subscribe:

A. Mutual defense of their territories. These territories are specifically set forth in the basic amendments.

B. Renunciation of aggression. An act of aggression is specifically defined in the basic amendments as (1) an attack with weapons of violence by a sovereign state or its citizens

against the territory of another sovereign state; (2) violation of the agreed controls over scientific weapons.

C. Changes in the structure of the Security Council, elimination of the veto power, and delegation by member states of specific powers to deal with aggression.

D. Limitation and control of the production of atomic and heavy arms in accordance with a specific production quota for each major state and a collective quota for the lesser states. The specific production quotas are set forth in the basic amendments.

E. Establishment and maintenance of a World Peace Force, with a special International Contingent.

The Security Council shall consist of ten members—two from the United States, two from Britain, two from Soviet Russia, one from France, one from China, and two selected collectively by the lesser states. Although all lesser states enjoy the same sovereign rights and privileges as the major state, they are treated for the purpose of representation as a collective unit, as though they were a single major power. Later, the Middle East shall have one Trustee, and eventually Germany and Japan shall also have one Trustee each. . . .

It is evident that a guarantee by the might of the United States of the agreed territories of Britain and other nations against any aggressor would automatically secure the adherence to the Federative Alliance of four fifths of the nations of the world, increasing by that much the future defensive power of the United States. At the same time, any risk for the United States of being involved in "wars not of her own making" would be negligible. Any nation that would dare to attack a mutual defense system that included the United States and four fifths of the world would be courting disaster.

The member-states delegate to the Council (whether it is the improved Security Council of the United Nations or the Council of Trustees of the Federative Alliance) three specific powers, all dealing with the elimination of aggressive war:

1. The power to inspect the territories of all member states, thus insuring the observance of the previously agreed quota limitation and controls of the production of scientific weapons.

2 The power to organize and manage a special armament trust to produce and control scientific weapons for the collective account of the lesser states

3. The power to organize and use a special International Contingent (recruited from the lesser states) as shock troops to enforce the Quota Limitation and controls, and to prevent aggression by or against member states.

The decisions of the Council are made by a simple majority vote (no veto right) within the scope of these three delegated powers.

In all other respects the sovereignty of each state is preserved as heretofore. In this manner, we obtain an effective and acceptable federative structure which is neither a league nor a world state, nor a compromise, but an entirely new type of international organization, created to fit modern conditions. The United States and other member states give up only the sovereign "right" to prepare for or to wage wars of aggression—a right which the American people have been willing to give up long ago. . . .

A large staff of inspectors, maintained by the Security Council will have the right of access to all laboratories, factories, mines, etc., in all member states. Individuals or groups who are found guilty by the High Court of violating the Quota controls will be subject to severe penalties. Governments which directly or indirectly support such violations will be deemed aggressors. Any member state opposing the right of inspection of the Quota limitation in its territory, or the right of the High Court to judge through a local jury and punish their citizens if found guilty of violations, will also be deemed an aggressor.

There will always be a time-lag between the conversion of peace plants into war plants and the accumulation of enough heavy armament for extended aggression. The Quota Force formula makes it impossible for any would-be aggressor to take advantage of this decisive time-lag.

The Formula for the Quota Control of Atomic Arms: In the case of atomic weapons, the goal must be the total abolition of the use of atomic energy for purposes of destruction. Should this be unacceptable at present, the Security Council must establish the same Quota Force limitation of production, with the same individual and collective quotas, as in the case of heavy weapons.

The total world production of atomic weapons must be set low enough to prevent irreparable destruction of the civilized centers of the world. The secrets and the processes of production shall be mutually exchangeable among member states.

The Security Council will at all times have the right to inspect not only the laboratories, factories and other centers of production, but every step in the process of production of atomic energy, from the mining of the pitchblende and other raw materials to the finished product. This right of inspection shall extend to the member states not yet producing atomic energy, in order to be sure that no state is producing atomic arms in secret. The recent war controls of the production of metals, particularly rare metals, have demonstrated that it is entirely possible to keep account of every particle of uranium or other fissionable elements produced in the world. It will probably be necessary for the Security Council to require the establishment in each country of a government monopoly of radioactive ores and their products, such as uranium or plutonium. A licensing system would permit private enterprise to purchase these products from the government for peaceful purposes.

With these rigid controls and inspection, it will be virtually impossible for any would-be aggressor to produce secretly enough atomic arms to start an aggression with any chance of success. It is true that an atomic bomb could be assembled secretly anywhere. But it must be remembered that the only materials from which atomic energy can be obtained in quantity so far are uranium and thorium, rare elements which will have to be collected in large amounts from enormous quantities of mined ores. The size and location of these mines certainly could not be concealed for long from the inspectors and other means of detection at the disposal of the Security Council.

The Quota Force formula not only solves the problem of controlling the production of scientific weapons. It also solves the centuries-old problem of an effective and yet acceptable international police force, without which any international structure is but a cardboard structure. It creates a self-balancing system of national armed forces which, though all-powerful against any aggressor, would be powerless to threaten the security of any

member state, large or small. This new type of international police force is called the World Peace Force.

The World Peace Force of the Federative Alliance consists of two different kinds of armed forces:

A. The National Contingents, which are the national armed forces of the Big Five; and

B. The International Contingent, which is recruited exclusively from the lesser states.

The National Contingents operate as reserves, when needed, of the International Contingent, which is the active part of the World Peace Force . . .

The International Contingent is equipped with atomic and heavy arms from the collective quota produced in the lesser states by the Armament Trust under the Security Council. Thus its effective strength is 20 per cent of the total world strength, equal to that of the United States, Britain, or Russia.

The International Contingent is stationed in selected bases of lesser member states in Europe and Asia, as well as in Germany and Japan, where it will constitute the only troops of occupation, and where the Council of Trustees will replace the present chaotic, costly and war-breeding rivalries of the Big Five. The cost of upkeep of the International Contingent will be borne, in proportion to their annual income, half by the Big Five and half by the lesser member states . . .

Any lesser state, if an aggressor, will face the crushing weight of the International Contingent. Any major state, if an aggressor, will face a five or six-to-one superiority of armed forces, led by the International Contingent, with the National Contingents of the remaining major powers as reserves.

Heretofore, any proposal for an international police force was either ineffective or politically unacceptable. If each major power retained the right to arm without limit, then any international police force would be ineffective, since it would not be strong enough to overcome any aggressor major power or combination of aggressors. If, on the other hand, the major powers were required to disarm as the price of establishing an adequate international police force, then the capacity of the major powers to defend themselves would no longer exist, and the international

police force might become a world military dictatorship. Because of this unsolvable contradiction, any proposal for an international police force heretofore made was rightfully considered visionary.

The Quota Force formula solves this Dilemma No. 1 of lasting peace It creates an overwhelmingly powerful World Peace Force against any aggression by any major state or combination of states, and yet it preserves the freedom of action and the relative power standing of all major states.

It was previously stated that the fundamental cause of aggressive war is the lack of an adequate central authority in the family of nations In order to establish such a central authority, three basic problems have to be solved: the problem of national sovereignty, the problem of limitation of armament, and the problem of an international police force Because our official peace-planners failed to solve these problems, the governments of the United Nations retreated to the hopelessly antiquated methods of leagues and alliances. The Quota Force system has solved these three problems by using modern methods based on the revolution in the nature of military weapons and communications With these basic amendments, the members of the Security Council will be able to vote by a simple majority because their delegated power is strictly limited and specifically defined; the control of scientific weapons is possible because of the nature of these weapons; and the international police is possible also because of the nature of scientific weapons and the revolution in communications.

The Quota Force system for the first time in history solves the problem of wars of aggression by attacking the means of waging war, which are few, rather than the causes of war, which are many. Only a few months will be needed to organize the Quota controls of scientific weapons and to set up the International Contingent Decades, if not generations, will be needed to remove the economic causes of war; and centuries will not suffice unless we first remove the greatest social injustice of all—war of aggression. In the family of nations, as in any organized society, the judge and the policeman, though not the most important, are the most urgent. Only after the many are protected against the violence of the few is it possible to proceed to the removal of the

deeper causes of war by higher economic standards, better social justice, and above all, through education and religion. Today, when nations are feverishly and secretly engaged in the discovery and unrestricted production of atomic weapons that will blast our civilization, world law and the world cop have become a matter of our very survival. This can be accomplished now and with justice to all by the Quota Force plan. No other plan can do it.

Every effort must be made to induce the other major powers—Britain, Russia, France and China—to accept these basic amendments to the United Nations Charter. As for the smaller states, since their only protection against aggression by a major power lies in the basic amendments, a majority of them will accept with alacrity. With these basic amendments, the United Nations Charter will be transformed from a timid beginning into a ringing challenge to all future warlords. The United Nations Organization will be strong enough to cope with the atomic threat. Its rapid development into a true world federation will be assured, and we can look forward with certainty to an era of lasting peace.

But in matters involving the destiny of nations, we must also assume another though less probable contingency, and that is the refusal of one of the major powers—Russia, for instance—to accept these amendments. Russia is—perhaps with good reason—the most suspicious nation in history. Her leaders may fear that this world collective front, being composed mostly of capitalistic countries, might be unjustly turned against Communist Russia. Russia may therefore decide to veto these amendments or to delay their acceptance.

In this event, the United States must proceed without delay to establish the Federative Alliance, incorporating the indispensable provisions contained in the basic amendments. Naturally, every effort consistent with the effectiveness of the Federative Alliance must be made to induce Russia to join it. But if she has vetoed or delayed the proposed basic amendments, she may at first refrain from joining the Federative Alliance for the same reasons; or she may even seek to oppose the establishment of the Federative Alliance.

The question therefore arises: Can an effective international organization for control of scientific weapons and aggressors be developed without Russia? The whole basis of the United Nations Charter is the assumption that it cannot. This is a grievous fallacy. The logical conclusion of this assumption is that the destiny of the United States and the future peace of the world is to be decided principally in Moscow. The practical result of this assumption was a United Nations Charter which, as it stands today, is powerless to prevent or stop aggression by a major power. The method of the Federative Alliance shows how an effective international organization can and must be established with Russia if possible, without her if necessary.

Regardless of whether Russia joins or not, Britain is certain to join. A guaranteed defense of the British Commonwealth and the Dominion of India by the might of the United States is a matter of vital necessity to Britain, which is surrounded on all sides by rising industrial giant-states. This defense can be assured to Britain through the collective security system of the Federative Alliance. In fact, the only way in which Britain or any other state can make certain of America's participation in their defense is through the Federative Alliance. If the American nation is part of such an effective international organization for collective security, open to all peaceful nations and directed against none, she will fulfill her obligations of mutual defense. But the American people will not fight to further the power politics interests of Britain or any other state, or to right the innumerable wrongs committed all over the world.

Britain brings into the Alliance a vast empire of 500,000,000 people with tremendous resources. The United States today possesses at least 70 per cent of the total world production and equipment of scientific weapons. In addition, virtually all of the Latin-American republics and the lesser states of western Europe are certain to join the Anglo-American federation, thus adding another organized bloc of nearly 300,000,000 people. It is virtually certain that both France and China will also avail themselves of the mutual guarantees of sovereignty and territories offered by the Anglo-American-lesser-states bloc. It follows that regardless of whether Russia joins or not, nearly four fifths of the world

could quickly be organized on the basis of the Federative Alliance. Once so organized, the necessary measures for the quota controls of scientific weapons and for effective defense against any aggression could be easily established, as follows.

In the case of lesser states, the Quota Force controls must be established regardless of whether they are willing to participate or not With the atomic threat hanging over the world, there is no need for the United States or other major powers to be subjected to the power politics maneuvers or stupidities of any lesser state. Their very survival depends on the Quota Force plan

In the event that a major power such as Soviet Russia should refuse to join the Federative Alliance, she will then be asked to enter into a Quota Limitation Treaty with the Federative Alliance, agreeing to limit her production of heavy and atomic arms in accordance with the quotas already described, which give her absolute equality with the United States. Russia will have the right to inspect atomic and heavy arms production in the member states, and the agents of the Council of Trustees will have the right to inspect Russia's production.

Should Russia refuse even a Quota Limitation Treaty, the Council of Trustees will have to establish the quota controls and World Peace Force without Russia Since only member states are protected against aggression by a non-member, there is little doubt that virtually the entire world outside of Russia would seek admission to the Federative Alliance, thus creating an overwhelming world collective front This collective front, though leaving Russia isolated, would not be directed against her. Her sovereignty and territories, from the Curzon Line to the Amur River, would still be guaranteed against aggression by member states.

In the case of heavy arms, the Council of Trustees would provide for an extra quota to take ample care of any possible secret rearmament in heavy weapons on Russia's part. This would make it hopeless for Russia, if such were her intention, to compete in heavy armament against the organized world.

In the special case of atomic weapons, a similar provision for an extra quota would apply even better, thus confronting Russia, if an aggressor, with the atomic power of the rest of the world. But it is highly improbable that the world collective front of the

Federative Alliance would need to go to such lengths, once it is established. The Soviet rulers are cold realists. They will be swayed by the considerations of the politico-military forces brought into play by the Federative Alliance, not by the design of some recalcitrant Communists to conquer both the world and its society. The Soviet rulers also are practical idealists, and the peace of the world is as dear to them as to anyone There would be little reason for Russia to remain isolated, once the Federative Alliance demonstrated its peaceful intentions toward her. The vision of world federation is traditional with all Russian revolutionaries, Communist or otherwise To eliminate aggressive war in the world is a far greater (and easier) revolution than to establish world communism. It is inconceivable, therefore, that Russia, in the face of an overwhelming world collective front designed to protect her as well as any other nation against the unparalleled evil of atomic warfare, would not grasp the opportunity to join with the rest of the world in blotting out this evil from the face of the earth.

Nothing but the foolproof and rogue-proof methods of the Quota Force plan can prevent a third world war, between Communist Eurasia and the western world, which is already in the making. Only hypocrites and innocents will claim that the present United Nations Charter can stop it. The Charter with its paralyzing veto power, its impotent "adequate force" and the total absence of enforceable controls of scientific weapons, merely records the good intentions of the allied peoples—and that is all. But the road to war is paved with good intentions. Only doughty old professors and demagogues, oblivious of time and atoms, can talk today of the slow, gradual evolution of the Charter by means of innumerable diplomatic conferences and revivalist meetings. Peace in the Atomic Age cannot be bought on the installment plan.

Although today the United Nations have achieved the greatest victory in history, fear dominates their relations. Communist Russia fears a coalition of the western democratic world, led by the Anglo-Americans. Therefore she seeks desperately to acquire more power and to expand into new spheres of influence while there is still time. The Anglo-Americans, and most of the world,

fear the rising giant-state of Communist Russia. Many see in the spheres of influence which Russia is now building a gigantic springboard from which the Soviet rulers hope to realize their hidden designs of conquest not only of the world, but of its societies. They suspect that Russia no longer wants, nor seeks, an effective system of international security, and that she embraced the United Nations Charter only so as better to strangle it. This is because time has become the ally of Russia and the enemy of the Anglo-Americans. Another ten years of the United Nations Charter and Russia will be the dominant power of the earth.

The whole point is that it does not matter what the motives of Soviet Russia are—whether she is building her spheres of influence for strategic defense against the Anglo-Americans, or as a springboard for eventual attack against the world, or for both. In a world of rampant military force, no great state can entrust its future to the solemn promises or purity of motives of other potentially rival states.

As a result, we are facing one of two wars, a thousand times intensified by atomic weapons: Either a preventive war by the capitalistic world led by the Anglo-Americans, within the next five years, to destroy the Russian Communist state before it acquires decisive strength in atomic and heavy arms; or, if this war does not take place, then a war fifteen or twenty years hence by Communist-dominated Eurasia to eliminate the hegemony of the Anglo-American world.

Either of these two wars would be a catastrophe of centuries. The only escape from both of them for a world now trapped by atomic and other devastating engines of destruction is to create a guaranteed international system whereby the Anglo-Americans would not threaten Soviet Russia today and the Russians could not threaten the Anglo-Americans tomorrow. We must establish now a new society of nations for the sole purpose of eliminating the international crime of aggression by means of rigid controls over the means of waging war and by using an overwhelming World Peace Force to stop and to punish any aggressor. If we do this and nothing else, we shall accomplish in the field of social science a revolution equal to the atomic revolution in the field of physical science.

Anyone who considers the Quota Force methods carefully will, I believe, agree that there exists no other effective and politically acceptable way to master the destructiveness of atomic and heavy weapons and to impose the peace of the many over the violence of the few. The Quota Force system contains all the elements necessary to stop both the atomic threat and all aggressive wars. When adopted, the way will be open for a true world federation, without which the Atomic Age will become the New Dark Age.

DOMESTIC CONTROL AND DEVELOPMENT OF ATOMIC ENERGY [7]

As Secretary of Commerce, I have a particular interest in the parts of these bills which relate to the potential economic uses of atomic power and the byproduct materials. However the several aspects of atomic energy—domestic and international, economic and military—are very closely related Each aspect affects the others to such an extent that the whole problem has to be considered before a satisfactory policy can be worked out with respect to any particular phase. This close relationship was brought out very clearly in the testimony of the scientists who appeared before your committee last month. I shall therefore first discuss some of the general aspects of the problem as background for my specific comments on economic, industrial, and other nonmilitary applications of atomic fission.

In thinking about these several bills, we must first determine the reasons why legislation is needed on the domestic aspects of atomic fission. What are the things that need to be done now in the domestic field, and how do they relate to the question of international control to prevent the use of atomic power as a military weapon? In his message to the Congress on October 3, 1945, President Truman clearly summarized the reasons for domestic legislation which were important at that time. Those reasons were:

1. To establish a peacetime organization to take over the plants and facilities developed during the war for the production of fissionable materials and bombs.

[7] By Henry A Wallace, former Secretary of Commerce. Statement before the Senate Special Committee on Atomic Energy. Hearings on S. 1717, 79th Congress, 2nd session. Part 2, p. 219-37. January 31, 1946. (S. 1717, revised, became law August 1, 1946—ed.)

2 To develop and direct a policy of further research on atomic fission and byproduct materials.

3 To secure control over the basic raw materials in this country.

In that message to the Congress, the President also stated that he would soon initiate international discussions for the control of atomic energy and for outlawing the use of atomic weapons. He pointed out that international arrangements for these purposes would be difficult to achieve, but that the alternative was a "desperate armament race which might well end in disaster."

Very important progress has been made in the direction of effective international cooperation since the President's message was delivered some three months ago A preliminary meeting with Great Britain and Canada took place in November. A further meeting was held in December in which Russia participated; and Russia, Great Britain, and the United States agreed to sponsor the establishment of an Atomic Commission of the United Nations to make recommendations to the Security Council on the following points:

1. For extending between all nations the exchange of basic scientific information for peaceful ends;

2 For control of atomic energy to the extent necessary to ensure its use only for peaceful purposes;

3 For the elimination from national armaments of atomic weapons and of all other major weapons adaptable to mass destruction;

4. For effective safeguards by way of inspection and other means to protect complying states against the hazards of violations and evasions.

The proposal for the establishment of an Atomic Commission was approved a few days ago at the first meeting of the Assembly of the United Nations in London.

Since the President's message of October 3, it is clear that a further very important consideration has developed with respect to domestic legislation on atomic fission—the need for consistency between our domestic policy as established in such legislation and the international policy which the United States has sponsored and which the other members of the United Nations have accepted in principle. That international policy is to bring about as soon as possible agreements among all nations not to develop or use atomic weapons, and to insure that such agree-

ments are effective by backing them up with an international inspection system We do not yet have such international agreements nor an inspection system, but our domestic legislation must be designed to fit into such arrangements and must not give other nations any reason to doubt that international control is our policy and that we would support that policy wholeheartedly. For example, we would undoubtedly give the other nations of the world reason to distrust our motives if on the international front we advocate a policy designed to prevent war and to prevent the use of atomic energy for military purposes, while we simultaneously place the scientific and technological development of atomic energy in the hands of the military at home. So long as we continue without legislation on this subject, we are doing just that In the eyes of the world, we are entrusting all of the nation's activities in the field of atomic energy to the military.

I now turn to an examination of the bills before your committee, and especially the McMahon bill (S 1717), the Johnson bill (S. 1463), and the Ball bill (S. 1557), in relation to the requirements for domestic legislation which I have listed. The requirement that domestic legislation conform to, and serve to carry out, the international policy to which we are committed is obviously the most important single consideration. Unless we can insure that atomic energy will not be used as a weapon, utilization of the power in the atom for peaceful purposes and for the welfare of mankind is only an academic consideration. If atomic weapons are ever again used in war, civilization as we know it will be destroyed. Those, if there are any, who survive the destruction will be concerned with the elemental problems of getting enough to eat and improvising some sort of crude shelter, and not with atomic power plants or medical applications of byproduct materials.

In order to be consistent with the international policy which we have proposed and which offers the only possible alternative to an atomic arms race and ultimate chaos, domestic legislation must be based upon the following principles:

First, it must provide for civilian control in complete harmony with our international policy.

Second, it must provide the basis for a free international exchange of basic scientific information, and for the exchange of technical information when international arrangements make that possible.

Third, it must provide for the early development of the best possible techniques for inspection, which this country can then offer and propose to the United Nations.

Perhaps some further discussion of the third point may be in order. As several scientists who appeared before your committee have testified, the United States knows so much more about the technical problems of inspection—because we are the only nation which has produced fissionable material in quantity—that we must take the lead in devising and proposing effective inspection techniques. The development of such techniques has not yet been possible because of the wartime secrecy rules which are still in force—the compartmentalization of information imposed by the military upon the scientists associated with the Manhattan project. Therefore the formulation of such techniques may need to wait upon the establishment of the Commission.

I shall now take up in turn each of the three principal bills concerned with domestic control and development and consider them in relation to the three standards of conformity with our international policy which have just been enumerated.

First, let us consider the McMahon bill (S. 1717). This bill was introduced after our policy of striving for international control of atomic energy had been formulated by the President and after the initial meeting of the President with the Prime Ministers of Canada and Great Britain. The possibility thus existed of making policy on the so-called domestic aspects of this problem conform to our international policy, and full advantage was taken of this opportunity. This bill places control of developments within the United States in a full-time, five-member civilian commission responsible to the President. Members of the Commission will be appointed with the advice and consent of the Senate, and will be removable at the discretion of the President.

These provisions are consistent with our traditions of democracy and would place control of development of this new tremendous force in the hands of agents directly responsible to representatives of the people. Such democratic control and responsibility are essential not only to prevent undesirable forms of authoritarianism or military dictatorship on the domestic front, but also to assure a domestic program consistent with our international policy. Moreover, the bill specifically provides . . .

> The Commission shall not conduct any research or developmental work in the military application of atomic power if such research or developmental work is contrary to any international agreement of the United States

The Commission is given custody of all atomic bombs, and is directed not to produce bombs nor to turn any over to the armed forces of the United States except at the express direction of the President. This is a fundamentally important provision which will assure the continuation of our traditional policy of civilian control of military matters. At no time in the history of the United States, in fact, has it been more important to follow the constitutional pattern of subordinating the armed services to civilian representatives of the people.

Secondly, S. 1717 places great emphasis on complete freedom for fundamental scientific research and on the free international exchange of basic scientific information. It provides further, in section 9, that related technical information shall be distributed—

> with the utmost liberality as freely as may be consistent with the foreign and domestic policies established by the President. . . .

Furthermore, the Commission is not only authorized but is directed to foster and develop economic, medical, and other peaceful uses of the process of atomic fission and byproduct materials resulting therefrom.

Finally, under the complete civilian control and with the close coordination with international policy which the bill provides, it is clear that the Atomic Energy Commission could quickly arrange for the development of the best possible tech-

niques for use in an international inspection system by the scientists, engineers, and technicians acquainted with all phases of the Manhattan project.

The Johnson bill (S. 1463) is defective with respect to all three criteria of consistency with our international program. Since the bill was drafted and introduced before our international policy was clearly formulated in the form of the declaration of the President and the Prime Ministers of Great Britain and Canada, it was almost inevitable that this should be the case.

The Johnson bill is essentially a bill for promoting further military developments of atomic power It turns the entire question of domestic development and use of atomic energy, including military developments and uses, over to a nine-man, part-time Commission and to an Administrator appointed by the Commission. The Commission and the Administrator are given powers which make them largely independent of the President and of the Congress. The Commission members are appointed for nine-year terms, and cannot be removed by the President except on specific limited charges. . . . Little positive encouragement is given to the Commission to sponsor and develop economic, medical and other peaceful uses of atomic power or its byproduct materials. The Commission is left perfectly free to manufacture, or have manufactured by private contractors as many bombs as it may see fit, and there is no specific limitation on the disposition to be made of such bombs. A yearly inventory of property, which presumably would include bombs, is required to be made to the President, but only such parts of that inventory need to be made available to the Congress as the Commission believes to be desirable.

The general statute which prohibits commissioned officers from holding civilian positions is set aside to permit military men on active duty to serve on the Commission, or as Administrator or Deputy Administrator . . . These provisions potentially place the people of this nation and even of the world at the complete mercy of a small group of men, perhaps a military clique, who could use this fearful new power to impose new and more terrible forms of authoritarianism and imperialism.

With respect to the second criterion, the bill does not provide for the free dissemination of basic scientific data, nor for the international exchange of technical data, if and when the President finds that international arrangements have progressed to the point where such exchange would be desirable. On the contrary, there is great emphasis on security regulations—which need not even be made public. There are drastic penalties provided for even unintentional violations of the statute or of security regulations. These provisions indicate again that military applications are the prime consideration of this bill, and under it that wartime security regulation would be carried over into peacetime.

This again is a place to mention, as so many of the eminent scientists who have been associated with the development of atomic fission have pointed out, that to carry security regulations and secrecy to extremes will soon place the United States at the bottom of the scientific world in nuclear physics instead of at the top. Such regulations stifle scientific progress. They are completely counter to the teachings of the history of science. Scientific endeavor requires an atmosphere of freedom conducive to pursuing the path of truth wherever it may lead. Under conditions of military secrecy, restriction and regimentation, the best-qualified scientists would not continue to work on atomic energy. They would leave the field of atomic fission and pursue research in other fields of scientific investigation.

Lastly, under this bill I doubt whether we shall get the scientific and technical collaboration which is necessary to develop, without further delay, the inspection techniques required for effective international control of atomic energy under the United Nations.

It seems to me clear that if S. 1463 or anything like it were enacted by the Congress, it would tremendously increase the difficulties of achieving and successfully administering an international control and inspection system. We would be proposing control and peaceful uses of atomic fission to the world on the one hand, and on the other, we would be turning our domestic development and use over to a virtually independent commission. The commission provided could be dominated and controlled

by the armed forces under a statute that emphasizes military developments of atomic energy. This is certainly not the way to encourage international cooperation. It is clear that this bill was not drafted to fit into a policy of international control of atomic energy. . . .

I now turn briefly to Senator Ball's bill, S. 1557. This bill seems to me to fall somewhere between the McMahon bill and the Johnson bill. It is clearly the intent of the bill to provide for civilian control of domestic developments and for coordination with our international policies. The nine-man Commission would consist of five Cabinet officers and four part-time public members. There is no restriction on the President's power of removal. Military officers on active duty are specifically barred from membership on the Commission or from serving as Administrator or Deputy Administrator. On the other hand, being less detailed than the other two bills, it does not provide much guidance to the Commission on many specific points of policy. It seems to me very desirable that the Congress spell out the policies to be followed by the Commission as far as that can be done at the present time, and not give to the Commission what amounts to a blank check on many questions.

I should now like to turn to the second major aspect of these so-called domestic bills—the economic, medical, and other nonmilitary applications of atomic energy. As your committee has already brought out in its hearing in December, this phase of the subject must also be considered in relation to the question of international control and inspection system. It was argued that with large-scale production of fissionable materials for economic purposes, inspection would become more difficult, and there might be more opportunity for clandestine diversion of fissionable materials to the production of bombs and other atomic weapons by a nation or groups determined to violate international controls. To my mind it would be most unfortunate if international suspicions, and the frailties and weaknesses of mankind, should force the world to forego even for a short time the benefits of the energy of the atom.

This is a matter which will have to be worked out and determined by all the nations concerned and will depend at least

in part on the effectiveness of the inspection techniques which qualified scientists, engineers, and other technicians have proposed after they have had an opportunity to study all of the technical problems involved. In any event, it will probably take several years to develop practical large atomic power plants, so that the question is not immediately before us. On the other hand, qualified scientists have pointed out that some of the materials produced as byproducts of atomic fission have important and immediate medical applications, which should be put into use by the medical profession without delay. Perhaps all that is needed in the domestic legislation is a provision that no development or utilization of atomic energy for economic purposes shall be undertaken which is contrary to any international agreement or policy of the United States. We should strive in every possible way, however, to find international solutions to permit the prompt harnessing of this new source of energy for the benefit of mankind.

With such a provision, I think the domestic legislation should properly provide every possible encouragement to research and development on economic, medical, and other nonmilitary uses of the process of atomic fission and its byproduct materials. The provisions of the McMahon bill on economic uses seem to me well conceived. This bill provides positive encouragement to research on nonmilitary uses of atomic fission and directs the Commission freely to distribute fissionable material in small quantities for this purpose.

The Johnson bill seems to imply that all sources of fissionable material—the raw ores—shall be owned by the government, and that mining extraction shall be carried on by the government. The McMahon bill seems to me to be preferable to the Johnson bill on this point, in that it provides for private ownership and extraction of ores, but requires that the sale and distribution of ores be carried out under government license.

With respect to patents, only the McMahon bill has any detailed provisions; the Johnson and Ball bills do not deal with this question at any length and presumably would permit private patents both on processes relating to the production of fissionable material and on devices for the use of fissionable material.

Since atomic fission may ultimately form the basis of a large part of our economic activity, it is clear that private patent monopolies on critical and key processes should not be permitted. The McMahon bill would eliminate private patent monopolies by requiring sale to the government of patents on all production processes, and the compulsory licensing with fair royalties to the inventor, of all patents on devices for the utilization atomic energy. I should like to suggest that with respect to devices essential to the production of fissionable materials, which will be a government monopoly or at least carried on only under government license and control, that another method may be preferable. It might be desirable to shortcut lengthy patent proceedings by forbidding private patents in this field and authorizing the Commission to purchase inventions directly from the inventor.

With respect to patents on devices for the utilization of atomic energy, the compulsory licensing provisions of S. 1717 seem to me to be essentially sound. However, it might be desirable for the bill to provide some definition of the devices which should be subject to compulsory licensing. As the bill is now worded, even trivial and unessential devices—such as a special stepladder or a pair of overshoes used in an atomic energy plant—would fall within the compulsory licensing provision. This seems to be unnecessary and may create a possible hardship for the inventors of such minor devices. Perhaps a criterion of broad public interest or the specification of antimonopolistic policy could be used to define and restrict the area of compulsory licensing.

Finally, on the question of patents, there is no provision in any of the three bills requiring that patents on inventions and discoveries resulting from government-financed research on atomic fission and related subjects be dictated to the public or turned over to the government. Such inventions may be extremely important, not only in the field of atomic fission itself, but in many ordinary industrial operations. For example, one of the government contractors at the Oak Ridge plant of the Manhattan district has issued a memorandum, with the approval of the War Department, stating that some 5,000 such new devices and improvements capable of ordinary industrial application were developed by this one company alone.

If the patent provisions of the Kilgore bill for a National Science Foundation are adopted by the Congress, no specific provision will need to be made in the atomic energy bills because the Kilgore bill provides for public dedication of all discoveries arising in the course of government-financed research and development. However, if that particular provision of the Kilgore bill is not enacted, I strongly urge that a similar provision be incorporated into the statute on atomic energy. . . .

There is one further provision in the McMahon bill on economic uses of atomic energy which requires special consideration Section 7 (d) provides that the Atomic Energy Commission shall not license any practical industrial or commercial use of fissionable materials until after a report on each such use has been prepared and submitted to the Congress by the Commission and after a ninety-day waiting period has elapsed following the submission of the report. During this period the Congress would have an opportunity to enact supplementary legislation regulating such use. This provision clearly extends an invitation to vested economic interests to bring pressure upon the Congress to prohibit or delay economic progress. To take a hypothetical example, let us assume that some future Edison will invent an application of atomic power that will make all present electrical power plants obsolete. It is clear that such a development might seriously threaten many vested interests—the interests of stockholders, bondholders, workers, and others. It may well be necessary for the Congress to take cognizance of such a situation and enact such legislation as may be required to minimize transitional hardships. It would be highly undesirable, and might well place this country at the bottom of the international scale in progress toward peacetime developments of atomic energy, if we were to prevent the introduction of such a new power plant in order to protect vested interests. . . . It seems to me very important, if this country is not to fall behind certain other countries in the adoption of this power to peacetime uses, that the diminution of the hardship involved in the transition be arrived at in some other way than slowing the rate of speed of the transition. . . . With section 7 (d) in force, the Congress will have invited a campaign to restrain the introduction of such a development, a campaign

which would undoubtedly magnify the immediate difficulties of present owners and workers and minimize the long-run benefits to the entire nation which would result from the new processes. With such a provision in effect during the last 150 years, can it be doubted that our technological progress and the rise in our standard of living would have been seriously retarded? We would have had strong pressures to slow up the introduction of all major technological developments—the steam engine, the power loom, the reaper, the automobile, the telephone, and the airplane. We dare not take the responsibility in history for a slowdown in the utilization of this greatest achievement of slow down in the utilization of this greatest achievement of science. . . .

In closing, let me summarize my views on the question of "domestic legislation":

1. Domestic legislation cannot be considered apart from our international policy on the control of atomic energy. Since international control to prevent the use of atomic weapons is by far the most important aspect of atomic energy, domestic legislation should be consistent with such control.

2. Domestic legislation should emphasize the development of peaceful uses of atomic energy.

3. Economic uses of atomic energy should to the maximum extent possible with safety and security be carried out by private enterprise rather than by government monopoly.

The McMahon bill meets the first two of these criteria, and would require only minor modification with respect to the third. The other two bills would require complete revision to conform to these standards. . . In coping with the problems, both international and domestic, created by the advent of atomic energy, this committee has the most awesome responsibility ever placed on a committee of Congress. In the hands of this committee, in the determinations of the Congress, rest the destinies not only of the people of the United States, but of the world. This committee has an opportunity for the exercise of vision, courage, and statesmanship which occurs only rarely in history.

No man can with clarity foresee the future developments which will stem from the harnessing of atomic energy. We are

probably standing on the threshold of a new and more far-reaching economic revolution than we have ever experienced in the past. The decisions which must be made are decisions which will determine whether mankind destroys itself or whether it finds the road to new and undreamed-of mastery of the secrets of the universe in the interest of a better life for all.

We must be prepared to deal with the human as well as with the physical problems which atomic energy will create. We must anticipate social and economic changes which may be effected by this new force, a need which the McMahon bill in its provisions requiring social and economic study forsees.

We can best deal with the great problems which face us by closely adhering to the fundamental principles of freedom and democracy so firmly rooted in our Constitution and in our traditions. We must insist on maintenance of the principle of government responsibility to the people—and avoid an atomic energy commission which is not responsible to the electorate or to its chosen representatives. We must insist on adherence to the traditional principle of civilian control over military matters—and avoid any possibility of military domination or dictatorship. We must insist on stimulating the development of peacetime uses of atomic energy through the channels of free private enterprise—and, as far as is compatible with public safety and welfare, avoid stifling and restrictive governmental operation, regulation, or control. We must assure the widespread use of atomic energy devices—and avoid the restrictive practices of monopoly. We must insist on following the fundamental precepts of scientific freedom—and avoid secrecy, suppression, or compartmentalization of knowledge. We must insist on the most rapid peacetime development possible of atomic energy—and avoid retarding such development because of any vested interest. Most important of all, we must insist on the utilization of atomic energy for the betterment of the human race—and avoid the pitfalls which would lead to the destruction of our civilization and international suicide.

These are the principles which should be incorporated into any bill designed to cope with the development and control of atomic energy.

THE VETO POWER PRO AND CON [8]

The so-called veto provisions are contained in Article 27 of the Charter, which provides that decisions of the Security Council on all matters other than procedural be made by an affirmative vote of seven members, including the concurring votes of the permanent members, namely, Russia, the United States, Great Britain, China and France—provided that, in decisions concerning the pacific settlement of disputes, a party to a dispute shall abstain from voting.

This provision of the Charter, like many others, emerged in substantially the original form drafted by the United States as far back as 1943 and presented to Britain, Russia and China at Dumbarton Oaks. The drafts submitted to the United States at that time by Britain, Russia and China had similar provisions.

In the resulting discussions, the right of the permanent members of the Security Council to veto enforcement action by the Council was not seriously questioned. Russia, however, favored a wider field for the veto than the other nations and would have expanded it to include decisions as to what disputes could be brought before the Security Council. So insistent was Russia that it was found impractical to reach agreement on this point at Dumbarton Oaks. It was only at the Yalta meeting that an acceptable middle ground was found as a necessary preliminary to the meeting in San Francisco, where the present Charter was finally agreed upon.

The basic concept of the veto was that the great powers that had contributed most toward winning the war and had the greatest stake and the greatest responsibility for maintaining the peace should have the right to prevent action against themselves or their vital interests by other nations. This concept may not have been entirely sound in theory or ethics. On the other hand, the framers of the Charter, faced with the problem of bringing together about 50 nations, large and small, accepted the veto provisions as the best obtainable compromise.

[8] Reprinted from *World Report* 1:26-7 July 4, 1946, an independent weekly magazine on international affairs published at Washington, D.C. Copyright 1946, United States News Publishing Corporation.

More specifically, the United States favored the insertion of the veto provisions in the Charter for three reasons:

(1) The veto was considered necessary to provide in legal form, under the Charter, a means by which the United States could protect its vital interests, without withdrawing from the organization and resorting to other effective means available to it.

(2) It was apparent Russia and Britain would demand the veto.

(3) It was generally agreed that, without the veto provision, the Charter would not get popular and congressional support needed for adoption.

Value of the Veto

The veto power has not worked out as intended. It has been used twice by Russia, in the case of Syria and Lebanon and in the case of Spain. In each case, Russia voted against a heavy majority of the Council, on the ground that the proposed action was inadequate. In the case of the Levant states, the proposed action was carried out subsequently by agreement between the states directly concerned, regardless of Russia's veto.

The veto, however, should not be summarily condemned on the basis of this limited experience. On the contrary, it should be recognized that, in a considerable degree, the veto serves to maintain the integrity of the United Nations by furnishing a legal method of blocking action that otherwise might disrupt the organization. Furthermore, it is apparent that the veto is so closely related to the comparatively fixed pattern of world power that it cannot be adjusted at will.

It is no accident that the United States, Russia, Great Britain, China and France are the nations granted this special power under the Charter. They are the "great" nations. On the other hand, they differ widely among themselves as to their national power and as to the veto's value to them.

France, in her possession of the veto, has legal power under the Charter that exceeds, in considerable degree, her actual power among the family of nations. By this veto, she can prevent

action against her under the U. N. that she otherwise might not be able to prevent. For her, therefore, the veto power is a very real element of protection.

China, in a degree and manner different from France, likewise possesses in the veto an element of protection that exceeds her actual power of self-defense. To China, in her present transitional stage of development, the veto is a great asset.

Great Britain, with an effective veto, is safe against any unacceptable action by the U. N. Without the veto, or in violation of it, however, she could not defend herself against either the United States or Russia. An effective veto under the U. N. is, therefore, of considerable importance to Great Britain.

The United States and Russia have a different status than other nations holding the veto. They not only have a legal veto under the Charter, but, because of their intrinsic power and inaccessibility, they actually have the equivalent of a veto outside the Charter. For this reason, the veto power is of less vital importance to the United States and Russia than it is to France, China and Great Britain. This situation does not alter the fact that, if the three great powers really cooperate, there can be peace, security and progress with or without the veto.

Proposals to change the veto power have taken two forms: (1) to abolish it outright, and (2) to curtail it under certain conditions, as exemplified in recent U.S. suggestions concerning the control of atomic energy.

In general, proposals to abolish the veto originate either with the smaller nations or with proponents of the so-called superstate, or world government. Such proposals from the lesser nations are entirely understandable, on the basis of national pride if for no other reason. The idea is particularly appropriate for home consumption. The smaller powers often express the fear that the great powers will dominate the world.

They must know, however, that, in the last analysis, a great power can dominate a lesser power, and they should realize that under the veto provisions of the Charter a small nation need have but one friend among the great powers to gain the protection of its veto. Australia may inveigh against the veto and champion the cause of the lesser nations, but somewhere there

must be a comfortable sensation as she contemplates the veto right of Great Britain.

Similarly, in Latin America—where pride of sovereignty is well developed—the protective value of a veto by the Colossus of the North cannot be overlooked entirely. Lesser nations in the Russian orbit surely will not let national pride mislead them as to the value of the Russian veto to them.

Veto and Atom Control

Proponents of the superstate consider the abolishment of the veto as an essential first step to world government—and it is. However, it is not alone sufficient that no member state shall have the legal right to thwart a world government; it is also necessary that no member state shall have the actual power to do so.

The legal veto may be abolished by agreement, but the equivalent of an actual "veto" inherent in the power of the United States and Russia cannot be abolished by law or treaty. It follows, therefore, that there can be no effective superstate unless these two powers cooperate on a workable basis for peace, security and progress. It follows, further, that if this situation happily comes to pass, the great world problem will solve itself, and there will be no need for a superstate.

The phase of the veto question of most immediate interest is that contained in the recent proposal by the United States now under discussion in the U. N. Commission on Atomic Energy. Under these proposals, the U. N. would take punitive action against any nation violating its commitments concerning the control of atomic energy. As regards such coercive action, no nation would have a veto.

The United States proposals leave a large field for future discussion as to the relationship between the enforcement functions of the Security Council and the Atomic Development Authority. However, only one solution seems practicable at this time—namely, that all enforcement functions be placed under the Security Council and a specific exception be made as to the veto power in enforcing atomic energy control agreements. It is

already apparent that Russia will find it difficult, if not impossible, to accept this loss of veto power and the inspections and control that would accompany it.

The United States proposal, on the other hand, is predicated on agreement among nations to accept inspections and control necessary to prevent the use of atomic energy as a weapon of destruction It is difficult to see how any nation that enters into such a revolutionary arrangement, whatever her mental reservations, could demand the right to veto action proposed in the arrangement for violation thereof. The whole arrangement necessarily would seem to include the part. We return, therefore, to the basic fact that the degree of cooperation needed to solve this vast problem would solve not only the specific veto question but actually would clear the way for full international cooperation and an era of security, progress and peace.

It is generally considered that the success of the control of atomic energy will be determined by the final attitude of Russia. Without attempting to evaluate what lies behind her present inadequate proposals, it is necessary to point out once more that whatever agreements are reached as to control, inspection and veto, neither the United States nor Russia, for the foreseeable future, can be coerced by any group of nations, whether it be in connection with atomic energy agreements or otherwise.

As a result of the above analysis, it would seem that:

(a) The veto power of the five great powers in the Security Council was a prerequisite to organization of the U. N.

(b) The United States, Russia and Great Britain are equally responsible for setting up the present veto system.

(c) Russia alone of the veto nations originally wanted and would still like to have a more extensive veto power.

(d) The veto power has not yet undergone sufficient tests to warrant definite conclusions as to its justification. So far, however, its use has tended to detract from its value.

(e) The veto power contributes an element of strength and permanence to the U. N. in providing a legal means of preventing action that otherwise might result in one of the

five great powers defying and breaking away from the organization.

(f) The veto power is so closely related to the relatively stable pattern of world power it cannot be altered at will.

(g) The veto provides a continuing source of irritation among the lesser powers, but it also furnishes them with a considerable degree of protection.

(h) Due to the veto power, France, China and, to a lesser degree, Great Britain have the legal right and ability to oppose action by other United Nations that in some cases are in excess of their actual and inherent power to do so. The veto is, therefore, of considerable importance to them.

(i) On the other hand, in the case of Russia and the United States, there is both a legal and the physical power of veto that is complete and equal. The veto power of the Charter is, therefore, of less importance to them than to other nations having the veto.

(j) In general, the importance of the veto is overestimated, since, if the three great powers work together, peace, security and progress will be attained with or without the veto and, if they do not work together, neither the veto nor lack of it will make any difference.

(k) Success in abolishing the veto as regards control of atomic energy would be an example of good faith and cooperation that would promise well for the future. On the other hand, while it would enhance the legal status of attempted enforcement action, it would not alter the fact that, in the last analysis, there can be no effective coercive action against either the United States or Russia.

PRIVATE VERSUS GOVERNMENT CONTROL OF ATOMIC POWER [9]

Everyone will agree that atomic energy is too important to the future of this country to permit any cartel, domestic or for-

[9] By Edward H. Levi, Professor, University of Chicago Law School. Statement before the Senate Special Committee on Atomic Energy Hearings on S 1717, 79th Congress, 2nd session Part 2, p. 108-11. January 25, 1946.

eign, to control its use or development. If there is any danger of a private monopoly in any of the stages of the development of atomic power, such as control over uranium or plutonium, or over any important process or application, the American people would want to prevent it.

As to many other industrial fields, we may have a split personality, condemning cartels as contrary to free enterprise, and yet tolerating them, because that is what a part of the rest of the world seems to want.

But it seems clear that the American people will not want to tolerate any private cartel controlling the development of atomic power in this country. In fact, the idea of such control seems fantastic.

But the idea is not fantastic, and any legislation in this field must take this possibility into account. After all, there is a cartel controlling radium, and radium is found in ores which also contain uranium. One company already has a dominant position over vanadium, and vanadium is found in ores which also contain uranium.

It may seem unthinkable that a cartel might be permitted to retard the development of a field important to national security. But the production of synthetic rubber was almost prevented in this country because of the control of patents by I. G. Farben and the various restrictive arrangements it had made. We are told that radioactive byproducts can play an important part in the development of medical research. Again we must be warned by the fact that the field of medicine and drugs is most highly cartelized and controlled. No American company wants to see these things happen in the field of atomic power.

In order to prevent these things from happening in the field of atomic power, legislation must guard against certain common practices or accidental results. For example, it is a common practice for an American company to make an exclusive cross-licensing arrangement with some foreign company under which patents and know-how are exchanged. A basic part of such an arrangement is an understanding between the parties that each party is to have a monopoly in the particular field in its own country.

Whatever we may think of such arrangements, whether they be considered legal or illegal under our present patent system, we cannot permit such agreements to restrict the development of atomic power. In fact when we are trying our utmost to encourage the development and beneficial use of atomic power, it would be anomalous to permit any company, large or small, or even an inventor to own any basic patent with the right to refuse to license anyone else to use the invented process or machine in the field of atomic energy.

In other fields it is perhaps possible that we may permit companies to acquire, accidentally or otherwise, key natural resources, such as bauxite, radium, or vanadium. But we cannot permit such a development for uranium. In other fields we permit companies to keep secret unique processes which they have developed, but in the field of atomic power, there at least should be no trade secrets against the government.

This means that legislation must give to the government special powers to prevent any monopolistic ownership of uranium or fissionable materials. It means that, as to atomic energy, our regular patent system must be modified. We can't afford to have blocking or fencing patents in this field. No company would want to assume the responsibility for preventing the widest possible development and application of atomic energy devices.

Legislation must make sure that, unlike the normal foreign business agreement between an American and a foreign company, the general public interest will override any exclusive arrangements. It must provide that our own country's foreign policy will have to control the development by American capital of foreign factories which might produce atomic bombs. And any commission set up by the legislation must have the right of access to all American plants and full information as to the state of the art.

This is the antimonopoly, the anticartel side of the picture. A part of the same picture, however, is that we want to discourage control by monopolies in order to make it possible for all American business to take part in this new development on the widest possible basis.

We want business to engage in research and developmental work in this field. We do not want research to be only govern-

mental or the work of nonprofit institutions. Thus it is important that the government have the right to give grants in aid and contracts for research and developmental work to private business enterprises. It is also important that some incentives be provided for private enterprise so that it will be anxious and willing to engage in research and developmental work.

What kind of incentives can legislation in the atomic energy field provide?

We may as well admit the fact that there are some incentives which good legislation in this field cannot provide at the present time. We cannot permit private enterprise in this country to begin the manufacture of fissionable material for the purpose of creating power.

There are two reasons why we cannot permit this. In the first place, the production of fissionable material by private companies for their own purposes and for the commercial sale of power will complicate the international situation enormously. It would tend also to foreclose the possibilities of an international authority under the U.N.O. which would not only have the right to inspect but the exclusive right to license the manufacture of fissionable materials throughout the world.

In the second place, we do not know enough about the commercial possibilities of atomic power to have intelligent legislation on that subject. And this is a matter which is so important that Congress must decide the issues.

While commercial and developmental work are going on in the industrial field, we will learn more about the industrial possibilities. When we learn more, then the Congress will have the information on which it can determine what the standards for industrial control should be.

And there is another incentive which good legislation cannot give to industry. This is the incentive of the exclusive right to control. In other words, whatever the right to refuse to issue a license under a patent may be worth, no company in the atomic energy field should have this right.

If legislation in this field should deny to private industry for the present the right to manufacture fissionable materials for the production of power and should deny the right to industry to possess patents which it can refuse to license, will there be suf-

ficient incentive so that industry will take part in the development of this new source of power? This is, of course, a crucial question which any legislation in this field must face.

The answer seems to be this: It is unthinkable that American business, given complete freedom to go ahead in research and development in this all-important field, will not do so. Industry can be given the fissionable material for its research and developmental work. The wide exchange of information should facilitate research. Industry can be given rewards for inventions not only through governmental contracts and grants in aid, but by receiving a royalty for the use of the inventions it develops.

Further, during the waiting period it can develop equipment or parts to be sold to the government. And industry will know that as soon as an international agreement has been reached and the Congress has the social and economic facts before it, additional legislation governing further commercial use will be passed. Industry undoubtedly will wish to take part in such studies as will be necessary before good legislation covering industrial use can be enacted.

I think that if industry is given the choice between intelligent legislation enacted after the social and economic facts concerning the industrial use of atomic power are known in greater detail, or legislation which perforce can provide no standards but which gives all-embracing and uncontrolled authority to a commission, industry will be on the side of intelligent legislation, and it will be willing to wait for such legislation while at the same time engaging in research and developmental work.

It is important that this should be so. This is the only way we can encourage peace in the world and at the same time begin to get the peaceful benefits of atomic power.

SCIENTIFIC SECRECY [10]

I wish to discuss one tremendously important aspect of atomic legislation: its provisions for maintaining secrecy with

[10] By Dr. Louis N Ridenour, representing the Federation of American Scientists Statement before the Senate Special Committee on Atomic Energy. Hearings on S. Res. 179. 79th Congress, 2nd session. Part 5, p. 535-40. February 15, 1946.

regard to the fundamental scientific content of what has been called the secret of the atomic bomb.

This question has been touched on in testimony before this committee. There is universal agreement that it is wise and useful to permit and even encourage full and free publication of all the results and findings of basic scientific work, provided only that this is not done on a unilateral basis—provided, in effect, that other nations will trade their scientific results for ours. However, some of the individuals who have appeared before you—for example, General Groves—have either implied or stated explicitly that it would not be wise for us to maintain such a policy of free publication of basic scientific work if other nations refuse to do likewise. I feel that this is entirely wrong. I shall try to show you that the interests of our nation will be better served by complete freedom of publication of the results of scientific work than by attempting to restrict the circulation of such information to a certain group in this country, in order to prevent its leakage to foreign nations who might be our enemies in a future war. In my opinion, this is true if no other nation in the world has a policy of free publication of scientific results. It is true whether we think that we have entered on an era of international peace, or believe reluctantly that we must prepare ourselves for inevitable war.

It is easy to make an idealistic argument for freedom of scientific publication: to say that the publication of results is the lifeblood of science, to assert that only by demonstrating our international good faith by a policy of free publication can we hope to set the stage for international trust and understanding I shall not make such arguments, because I do not believe that they cover the present case. Our nation is clearly committed to an atomic armament race at least as an interim national policy; the fact that we are still manufacturing and storing up atomic bombs admits of no other interpretation. There are evidences that other great nations are ready to enter into this race with us. Under these conditions, we must make plans in the light of the possible failure of the measures now being taken for securing international agreement on inspection and control of atomic energy. I shall therefore confine my remarks to the desirability

of freedom of scientific publication in an era of international suspicion, during an armaments race, and even in the midst of a war.

C. F. Kettering has said: "When you lock the laboratory door, you lock out more than you lock in" In the radar field, we started with the same atmosphere of secrecy, the same precautions about compartmentation of information and clearance of individuals, which characterized the atomic bomb project right to the end, and still characterize it today. However, we did away with most secrecy before the end of the war At the end of the war, the Army was publishing a magazine on radar with a circulation of over 12,000. It had become by that time apparent that secrecy cost us in efficiency far more than it gained us by keeping the enemy in ignorance. We found it a lot harder to inform the enemy than readers of spy stories may think. In the spring and summer of 1943, Allied aircraft were finding and killing German submarines at a rate not far from one a day, by the use of a new type of radar. There was literally no more important problem to the German high command than to find out the nature of the device our aircraft were using. Exactly the same radar was then in use by Allied bombers attacking Germany; and the inevitable losses of such aircraft scattered this radar—about which the German Navy was so eager to learn—all over Germany and the occupied countries. Despite all this, six months elapsed between the loss of the first complete equipment to the Germans and their realization that this was the radar their submarines had to combat.

The use of the word "secret" for the results of scientific investigation or the findings of engineering is genuinely misleading. Let me illustrate what I mean. If I say, "I am thinking of a number, but I shall keep it a secret," I have used the word "secret" in its usual sense. Apart from the possibility of my telling you the number, you have no way of knowing it or of finding out what it is. On the other hand, if I say, "I know the critical mass of U-235 necessary to make a bomb, and I intend to keep it secret," I am using the word "secret" in an entirely different sense. I am saying to you, not that you cannot find out what I know, but that you must find it out for yourself, without

my help. This may cause cause you to become annoyed with me, but it cannot keep you in ignorance.

In order to be sure that I am keeping such knowledge from you, I must also keep it from some of my own people. Since it is never known, in science, which man will have a new idea, or what each man must know in order to have the ideas and do the work of which he is capable, I am hobbling my own work by my misguided belief in the usefulness of scientific "secrecy." Arbitrary exclusion of a certain number of my own scientists from full knowledge of my progress removes entirely the usefulness of these men.

This is really the crux of the argument. If we can hide nothing permanently by scientific secrecy, then it is clearly undesirable, for it slows our own progress. Scientific history is full of coincidences—of cases in which two or more men, in different parts of the world, have reached the same result and independently of one another's work and at the same time Dr. A. H. Compton, an outstanding figure in the work on the atomic bomb, was awarded the 1927 Nobel prize in physics for his discovery of what is now called the Compton effect—the inelastic scattering of light quanta by free electrons. In Holland, this is called the Debye effect, because Compton's explanation of his experiments was given independently by Debye at the very same time.

The Russian physicist, Gamow, and Gurney and Condon—the same Dr. Condon who is scientific adviser to this committee—gave independently and at the same time an explanation of the phenomenon of alpha-particle disintegration of the radioactive elements. The very phenomenon of nuclear fission itself, the basis for the atomic bomb, was only foreshadowed by the work of Hahn and Strassmann in Germany. The hypothesis of a violent splitting of the uranium nucleus was independently proposed and verified by Frisch in Copenhagen and by Joliot in Paris. The suggestion that plutonium would be a suitable explosive for an atomic bomb was made in this country by Prof. L. A. Turner. The Smyth report points out that the same idea occurred independently to the British physicist Cookcroft, and Turner has told me that Von Halban, working in France, had the same idea at the same time.

Two promising new devices for the acceleration of electrons and atomic nuclei to high energies were invented last fall by two young American scientists. One, called the synchrotron, was invented by McMillan, at Berkeley; another, the microtron, by Schwinger, at Harvard. In the summer 1945 issue of the Journal of Physics of the U.S.S.R., a Russian physicist named Veksler published a paper describing these two devices. Though the scientific shades had been down between Russia and the United States during the war, after five years we find Russians and Americans doing the same things, in the same way, at the same time. The synchrotron involves a magnet, whose design is straightforward but complicated. McMillan is presently building a synchrotron, on funds supplied by the Manhattan district. When a physicist at M.I.T. [Massachusetts Institute of Technology], who is also planning the construction of a machine of this type asked McMillan for his magnet design, he was told that the Army would not permit the release of information on the magnet. Who are we attempting to handicap by such restrictions? Surely not the Russians; they not only invented the synchrotron, they did it earlier than we did.

In my own wartime field of radar there were many examples of the same kind. Radar itself was independently invented by the Germans, the French, the British, the Japanese, and ourselves. Each of these nations kept it secret from all of the others, not knowing to what little point this was done. Microwave radar, which has played such a great role in the Allied victory, was made possible by a single invention, the cavity magnetron. This is a transmitting tube which gives previously unimaginable amounts of power on wavelengths far shorter than those available to radio engineers before the war. It was invented by the British. When the British sent a scientific mission over to this country in the late summer of 1940, one of the most impressive of the secrets they had to show us was the cavity magnetron. When the radiation laboratory was first set up, an attempt was actually made to keep knowledge of the magnetron localized in one group of the laboratory, not even letting the men who were working on a modulator to energize this tube know of the tube's design. Yet, all this time there was in the Russian literature a

paper which exactly described the cavity magnetron, and gave the results of experiments with it.

In the light of all this evidence, and more of the same kind which I could quote for hours, you must forgive scientists for being impatient with talk of "the secret of the atomic bomb." The Army's policy respecting the release even of the most peripheral information obtained by the Manhattan project has been much too restrictive. Today, for example, more than eight months after the explosion over Hiroshima, the entire nonsecret literature covering the immense amount of medical work on the effects of radiation and of radioactive poisons on living tissue is to be found in section 8.70 of the Smyth report. Quoted in its entirety, it is: "Extensive and valuable results were obtained." Even in an armaments race such as that we are in today, even in the war to which such an armaments race is likely to lead us, how do we benefit by withholding the results of such investigations in medical fields?

Some of my friends who have had no contact with the bomb project have been interested in speculating on the problems which surround the atomic bomb. Only a law providing for thought control on the Japanese pattern would make it an illegal breach of security to tell you the results of this speculation. It may be interesting for you to compare some of the results of this speculation with the things you have been told as "secrets" in executive sessions of your committee. Such results can be equally well deduced by the physicists of any second-rate world power on the basis of the completely available published information on nuclear physics. If you feel it is proper, I shall be glad to tell you of some of these speculations.

I cannot presume to advise this committee of the detailed way in which a bill for atomic energy control should provide for peacetime secrecy restrictions on the publication of scientific work. It is my opinion that all of the bills so far presented go much too far in the direction of imposing such restriction. There would be little purpose served by full publication of instructions for the manufacture of an atomic bomb, and I believe that it is wise to restrict the publication of information concerning finished military devices.

On the other hand, there is no benefit to us, and there can be very serious harm, in restricting the performance of experiments or the publication of results in any field of basic science, nuclear physics included. The definition of "basic scientific information" in S. 1717 in my opinion is not valid It is important to publish not only the end results of scientific work, but a detailed description of how they were obtained. It is only this practice which distinguishes modern science from medieval alchemy.

We can make an analogy with the way other weapons are handled. The design of guns is kept confidential; yet the metallurgy of steel is dealt with in the usual way. Military aircraft are designed in secret; yet the aerodynamic principles on which they are based, and even techniques such as flush riveting, are freely published and available to all. It is thus that scientific and engineering progress is made.

Advocates of secrecy in science feel that it will advance our national security and strengthen our national defense, else they would not advocate it. All of the evidence available to me shows that scientific discovery and engineering development cannot flourish fully except under conditions which allow all competent men to be fully informed, and thus able to contribute to progress. We shall weaken, not strengthen, our national defense by any restrictive measures on performance or on publication in scientific fields. . . .

SENATOR HART. Doctor, may I ask one question, in your own field of radar? It is true, is it not, that we were way ahead of our enemies in this last war in our adaptation of microwaves?

DR. RIDENOUR. Yes, sir, that is true; and my belief, based on five years of observation, is that our leadership in this field was entirely due to the fact that the barriers of secrecy were broken down entirely between our Army and our Navy and among all three armed services of the British and between the British and ourselves, so that there was an enormous team of perhaps 10,000 scientists and engineers working together with full knowledge of the progress of the whole group. They advanced the art so fast that our enemies, who were still interested in engineering secrecy in this field, could never keep up.

SENATOR HART. Yes, but carrying your argument to its logical conclusion and making the assumption that your enemies could have obtained the information at the same time we did would have meant that we would not have weapons superior to them.

DR. RIDENOUR. Well, sir, I question that, if I may, because we must distinguish between knowledge and performance. That is to say, it is not enough to be informed of the results of a scientific experiment or of the design of a particular device. It is still necessary to make use of this information in the performance of another experiment, or in the manufacture and employment of the device. It is my contention that one must not make a small advance in a certain field and say "Now, I must keep this secret so no one catches up with me." He, must say, "I must tell this to everyone, to the competent scientists and engineers, and I will keep ahead of everyone."

EXCERPTS

There seems to be much confusion today as to whether or not our British scientists are in full possession of the so-called secret of the atomic bomb Contrary to what President Truman may have led some people to suppose, our scientists are, in fact, in possession of every detail of manufacture, every scientific secret —in short the whole technical "know-how" as to the production of the atomic bomb. American scientists have exchanged scientific information with British scientists, and unless a progressive attitude is adopted in place of our present attitude, I believe that the scientists both of Britain and America might themselves take independent action, and for my own part I would not blame them for so doing.

What is happening today in the United States of America? Only a tiny fraction of the enormous expenditure of capital, materials and labor is being devoted to the peacetime uses of atomic energy. Well over 90 per cent of the effort goes to producing bigger and better bombs for an undefined purpose. President Truman regards this as a sacred trust. Why, then, does

he not concentrate on the cheap production of power through the release of atomic energy, in which case in a comparatively few years men would no longer have to go down into the belly of the earth to hew coal, oil could be outdated, gigantic schemes of irrigation could make the desert blossom like the rose? Moreover, there is a tremendous medical side to the release of atomic energy. By it a radioactive species of every chemical element can be prepared which would be of inestimable value in medicine, both for the purposes of research, for diagnosis and for therapy. If, by building bombs instead of by ending men's drudgery and by solving the secrets of nature, the President thinks that he is discharging a sacred trust, then he must be mistaking Lucifer for the Almighty.

The story becomes even more anxious when one inquires what firms are, in fact, managing plants on behalf of the American War Department that are now producing bigger and better bombs. Their names are indeed "names of fear, unpleasing to a Russian ear." The enormous factories are managed by the firm of Du Pont which, as is well known, had agreements with Imperial Chemical Industries of this country and with I. G. Farben of Germany, agreements which provided for their revival after the war and which are quite reasonably regarded, in Russian quarters, as having been part of an encirclement policy directed against them.

We should dissociate ourselves at the earliest possible moment from these interests. We should associate ourselves with progressive opinion, and with the scientists who are unanimous that, at the earliest possible moment, we must get back to the peacetime exchange of scientific information.—*Captain Raymond Blackburn, Labor Member of Parliament for Kings Norton, England. New Republic. N. 19, '45. p. 663.*

I have said that the issue of the veto in the realm of atomic control is unreal for the reason that the atomic bomb is too strong for the veto to affect it. Once a nation goes in for the illegal manufacture of the atomic bomb, it doesn't matter how much of a veto right there is on paper, the rest of the world will take action against that danger. Assuming that a system of

control has been adopted, that the crime of the illegal use of atomic energy has been defined, that punishments have been fixed, inspection has been organized, courts have been established or designated to pass on the evidence, the veto ceases to have any meaning. For if nation X breaks those laws, or if nationals of nation X break them, and have the support of nation X, the rest of the world will act, veto or no veto. For the atomic bomb is too powerful to permit inaction. And the nation which is illegally making the bomb already is at war with the rest of the world. So it is unnecessary to insist on a formal renunciation of the veto power in such circumstances. The renunciation as well as the veto are meaningless.

To put it another way, there can be no veto of punishment for the violation of a law. The job of the Atomic Energy Commission is to draw up laws for control The veto can be used in drafting the law. As a matter of fact, each sovereign nation has a veto, whether it is so called or not, when treaties are being negotiated or drafted. It doesn't have to accept a treaty or any part of it if it does not like. But once the laws are drafted, and the treaty is adopted and ratified, there is no veto power by which the operation of law can be called off. That happens not to be the veto power which the Russians cling to, and which they have made themselves obnoxious in using.

Let me say again that the veto power is an essential part of any organization of sovereign nations, for otherwise a majority of nations can decide the course to be followed by another nation, even to the extremity of forcing that nation to go to war. At this moment, when the Russians are playing a lone hand, and saying no to everybody and everything, and doing it with a tantalizing lack of rhyme or reason, the impulse is to say the fault is in any nation having a veto. But that is not the fault. The fault is in the Russians for not cooperating in matters not affecting their security, and not limiting their sovereign right to situations in which they are heading into danger.

It might be that one day the United States will be in a minority. Other countries might wish to force us into a war which violates some principle dear to us. This is not probable but it is not impossible. And not to have the right to veto such

a decision would be unthinkable But here again, as a matter of fact, we should exercise the veto whether we had a formal right to it or not.—*Raymond Swing, Radio transcript, June* 28, '46. *American Broadcasting Co. New York.*

The development of atomic energy and of its administration on a world level and the utilization of its force for peace rather than destruction, as I see it, should be through the growth of the United Nations Organization.

I suggest that the United States propose an amendment to Article 43 of the United Nations Charter, an amendment granting to the Security Council the right and the duty to establish and maintain a small United Nations Air Force of five bomber squadrons and ten fighter squadrons, manned by volunteers from the United Nations, not more than one fifth of the personnel of any squadron to be of any one nationality background, to be based at five different suitable bases around the world, to be financed by a small tax on all international travel, and that the United States furnish five atomic bombs to each of these bomber squadrons at the five bases around the world to serve as the stabilization force for world order.

I suggest the United States propose an amendment to Article 26 of the United Nations Charter providing that no nations shall manufacture an atomic bomb, that the manufacture or possession of such a bomb would be a crime against mankind. The present plants would manufacture the number required for the World Stabilization Force, and then stop.

I suggest that the United States propose to the United Nations that the Security Council be given the right and the duty to establish an Atomic Commission of distinguished scientists, with the power and the duty to inspect thoroughly all nations, including our own, to keep accurate records of fissionable material, to ascertain their fulfillment of the foregoing charter provisions.

I propose that no one shall engage in any nuclear or atomic research without registering with this United Nations Atomic Commission, but that, once having registered, any scientist would be entirely free to carry on scientific research and to publish his

results to the world. I wish to emphasize that scientific freedom is just as important as academic freedom or freedom of the press to our way of life. The registration should be merely for the protection of mankind as to the location of the research, and to facilitate the inspection of the activities. . . .

The broad policy I advocate means specifically that we must do more than give lip service to the United Nations Organization. We must do more than cooperate in a manner of detached aloof interest. We must seek constantly to give it vigor and vitality and contribute to its growth. I know there are those who speak of its inadequacy. It is true, as I said long since, that it is only a "beach head in the battle for peace," that it is only "a very small step in the right direction."

But it is nevertheless a tremendously important step. It is a vital beach head. It has brought together all of the essential elements for effective word administration. It directly and indirectly represents three fourths of all the peoples of the world and can speak for all. Its purposes are right. . . . Its machinery and power are limited. Its veto is restrictive. But it is flexible. It can grow. It can be amended. It can be changed. Do not sell the United Nations Organization short. Do not undermine what you have in an academic discussion of what you wish you had. The United Nations Organization can be developed in any manner the United States, the Soviet Union, Great Britain, China and France, and a majority of the other nations wish it to be developed, and, realistically, there cannot be effective world government without the agreement of these powers.—*Captain Harold E. Stassen, U.S.N.R.; former Governor of Minnesota. Academy of Political Science. Proceedings. Ja. '46. p.* 106-10.

The problem [of inspection] can be divided into two parts: First, to ensure that no material is illegally diverted from known plants; and second, to discover any attempts to build and operate a secret diffusion plant. If a plant is operating, openly or secretly, one basic check that may be suggested is to keep an inventory on all uranium from the ore reserves, through the mining, refining and processing, to the final product and wastes. If

this is feasible, it would be a very powerful method for preventing the misuse of products of the diffusion plants. Specialists in the fields of geology and mining, in metallurgy, in uranium and fluorine chemistry and in the gaseous-diffusion process itself, would all be needed to work out this problem.

In addition to the inspection of all physical aspects of atomic-bomb plants and their raw materials, there may be viable methods of inspection involving the scientific and technical personnel necessary to develop, design and operate such plants. The questions that must be answered to determine the feasibility of these methods involve the following points:

1. The possibility of making a complete check of all the scientific and technical personnel in every country to ensure that no important number are being secretly trained and diverted for the development and construction of large-scale atomic bomb plants.

2. Any intended violation by a given country of the international-control agreement will of necessity be known to some of the scientific and technical personnel in that country. Because of their overwhelming desire for maintaining the security of the world, we feel that there will always be a certain percentage of these scientists and technical men who will report violations to the international-control commission. On this account, international and national laws should encourage and offer definite protection to those who report violations.

3. In order to prevent the secret disappearance of key scientific and technical personnel and in order to detect discoveries and developments which may lead to new methods for the production of fissionable material and atomic weapons, it is desirable that there be a rather thoroughgoing interchange of scientists and technical men. In addition, as a further safeguard, there should be complete freedom of publication of all scientific and technical discoveries and developments.

Undoubtedly no system of inspection could be absolutely certain to prevent secret production or diversion of fissionable material for illegitimate uses. However, under a good inspection system, the chance of evading inspectors becomes small, so small, in fact, that in all probability the risk of being caught in a vio-

lation would deter any nation from such an attempt. Furthermore; a good inspection system would create among all nations a greater feeling of confidence in the behavior of their neighbors. Such a feeling of security would in itself render the secret production of atomic armaments much less likely.

While the scientists and engineers seem to feel that an international system is technically feasible, it is quite clear that an adequate study of this problem has yet to be made. Statements concerning feasibility have been based upon the limited information available to individuals A complete picture involves the ideas and information of many experts, within and without the atomic bomb projects Until some means of coordinating this information is provided, a real analysis of the feasibility problem cannot be made —*Clarke Williams, College of the City of New York. New Republic. Ja.* 28, '46 *p.* 120-1

PEACETIME BENEFITS OF THE ATOMIC AGE

THE PEACETIME IMPLICATIONS OF THE RELEASE OF ATOMIC ENERGY[1]

Of much more interest [than the destructive uses of atomic energy] is its use as man's willing servant. In the long run it can hardly be questioned that the peaceful applications of atomic energy will be those that will most profoundly affect our lives. What these important applications will be is, however, as difficult to predict as it would have been a century ago, just after Faraday laid the scientific basis for electrical engineering, to tell the future meaning of electricity. At this moment the obviously great field open to atomic energy is that of production of useful heat and power. We also see important though limited medical and industrial applications of radioactive materials, artificially produced by atomic chain reactions Perhaps more significant than either are the new vistas that will be opened up by scientific experiments that make use of the by-products of atomic fission.

Such has indeed been the case with such discoveries as X-ray. Fifty years ago it was evident that X-rays were useful for "seeing" through objects, such as the human body, which are opaque to ordinary light. It could not be predicted that X-rays would become a powerful weapon in the fight against cancer, or that researches made by X-rays would reveal the electron and with it give us the radio and a host of electronic devices.

Such unforeseen developments are the result of every great discovery of science. It will nevertheless be worth noting some of the definite practical applications of atomic energy that we can now see clearly before us:

At present, controlled atomic power in the form of heat is in continuous production in large quantities at several plants,

[1] From article "Atomic Energy As a Human Asset," by Arthur H. Compton, Chancellor, Washington University, St. Louis, *American Philosophical Society. Proceedings.* 90, no. 1:74-9. January 1946.

especially those at Oak Ridge, Tennessee, and at Hanford, Washington. The heat from these plants is a by-product, and is carried away in the one case by air and in the other by a stream of water. The useful product is neutrons which are used in the plants as a means of transmuting certain chemical elements to others of specially useful characteristics. Of these transmutation processes the most important one is that of uranium into plutonium. Previous to the fission chain reaction the most abundant source of neutrons was the cyclotron which operates on electric power. Per kilowatt of energy used, the fission chain reaction gives some 10,000 times as many neutrons as a cyclotron, and it is not difficult to make a fission chain reaction plant that delivers 100 times as much power as is used by a cyclotron. This means that right now we are using large amounts of atomic power many times more efficiently for the particular process of producing neutrons than the best electrical machine that we have been able to devise.

Looking to the future, we may expect the use of neutrons as a means of producing new elements by transmutation to become of increasing importance. Plutonium is a concentrated source of available energy and will be a valuable material for peaceful purposes as well as for building weapons.

Other artificial radioactive elements, especially radioactive ones, will also find use in medicine, in industry, and in many branches of science. It is yet too early to see clearly how important these uses may become.

We have not yet built an atomic power plant that is generating electrical power. This is merely because we have been engaged in winning a war and there has been no serious shortage of electric power. If there were sufficient demand for a demonstration, a reasonably efficient plant using super-heated steam for driving a turbine could be put into operation within a year. Before, however, such plants can be made economical competitors, with existing practice, a number of years' development will be required.

While there are several other possibilities, the most obvious method of producing power from atomic fission is to heat a cooling agent such as air or steam or liquid metal in

the chain reactor unit and pass this heated coolant through a heat exchanger which heats the steam for driving a turbine. Beyond the heat exchanger of such a plant everything would be done according to standard practice. Up to the heat exchanger all the design requires new features, among them protection against the extreme radioactivity of everything, including the coolant, that has been exposed to the neutrons.

The chain reacting unit itself can assume many forms. The one essential is that it shall contain a fissionable substance such as uranium, either in its natural state or, if a small unit is desired, enriched with additional U-235 or plutonium. H. D. Smyth, in his official report, has described in some detail how this active material can be combined with a moderator such as carbon or beryllium or heavy water so as to bring about the chain reaction.

The large atomic power plants now used for producing plutonium have in them many tons of natural uranium and graphite. By using uranium containing more than the usual fraction of U-235, chain reacting units have been built that are of much smaller size.

There is, however, a lower limit to the size and weight of an atomic power plant that is imposed by the massive shield needed to prevent the neutrons and other dangerous radiations from getting out. Next to cosmic rays, these radiations are the most penetrating that we know and, for a plant designed to deliver for example no more than 100 horsepower, are enormously more intense than the rays from a large supply of radium or an X-ray tube. To stop them, a shield equivalent in weight to at least two or three feet of solid steel is needed. There are basic laws of physics that make it appear very unlikely that a lighter shield can be devised. This means that there is no reason to hope that atomic power units for normal uses can be built that will weigh less than perhaps fifty tons. Driving motor cars or airplanes of ordinary size by atomic power must thus be counted out.

Prominent among the advantages of atomic power are the extraordinarily low rate of fuel consumption and consequent low cost of fuel, the wide flexibility and easy control of the

rate at which power is developed, and the complete absence at the power plant of smoke or noxious fumes. With regard to fuel consumption, when completely consumed, the fission energy available from a pound of uranium is equivalent to the energy obtained from burning over a thousand tons of coal. With the prewar price of uranium oxide at roughly $3.00 per pound and of coal at $3.00 per ton, this would mean the economical use of uranium as fuel if only one part in a thousand of its available energy is used. Actually we should expect the first plants built for producing atomic power to be considerably more efficient than this in their use of the fission energy which would mean a substantial cost advantage in favor of uranium. One must consider also, however, the need to purify and fabricate the uranium into the desired form. For certain types of power plants under consideration, some separated U-235 is required and this is expensive. Attempting to consider all such factors, it appears that the fuel cost of the atomic power plant of the future will nevertheless be small as compared with the corresponding fuel cost of a coal burning plant.

In considering the economic aspects there are, however, many other factors. It is not really possible for these to be explored until we have actual experience with atomic power plants. First is the capital cost. Clearly, if one must charge against the capital cost what is spent in research and development, this cost is very high indeed. If, however, one looks down the line to a billion dollar a year national industry based on atomic power, the nation can afford a considerable investment in the research and development required to bring this industry into being. When this development is completed, it appears not unlikely that the cost of building and maintaining a large scale atomic power plant may compare favorably with that of a coal consuming plant of the same capacity.

Much remains to be learned, however, regarding the metallurgical and other technical problems involved in constructing a successful plant to transform fission energy efficiently into high temperature heat. The materials to be used may be expensive. The designs are, nevertheless, essentially simple. An inherent advantage of the atomic power unit is that the heat sources, i.e.,

the uranium blocks, can readily be maintained at any desired temperature regardless of how rapidly the heat is being removed. This means that a relatively small sized heater unit will be needed and that corrosion due to excessive heating is controllable

The terrific blasts produced by the atomic bombs have led to unwarranted fear of accidental explosions resulting from the normal use of atomic power. Explosions such as destroyed Hiroshima cannot occur accidentally. Such explosions must be carefully planned for. The dangers of explosions of the "boiler" type with an atomic power plant are about the same as with a steam plant, which is to say they are practically negligible if the plants are designed and handled by competent engineers.

There is, nevertheless, real possibility of damage to health of the operating personnel from ionizating rays emitted by the plant itself and by all materials that are taken out of the plant. These materials could also become a public hazard. This is the problem of the health of radium and X-ray workers on a grand scale. That the problem can be solved is shown by the fact that in all of the operations of the existing half dozen or more such plants, some of which have now been working for years, not a single serious exposure has occurred. This, however, is due to the thorough inspection and vigilant care given by the health staff headed by Dr. Robert Stone. In some of the experimental work we have not been so fortunate. Until we become much more familiar with nucleonics than we are at present, atomic power plants can be safely operated and serviced only with the help of health supervisors who are familiar with radiological hazards.

All of this points toward using atomic power first in relatively large units where careful engineering and health supervision can be given. An obvious suggestion is its application to the power and heat supply of cities and of large industrial plants. Within ten years it is not unlikely that the power companies designing new plants for city service will be considering favorably the use of uranium instead of coal for purely economic reasons.

This of course does not mean that atomic power will put coal out of business. Each will have its own field. For small heating units, such as the kitchen stove, atomic power has no place. If our national economy grows as it should, coal as a chemical agent, as for example in blast furnaces and preparation of organic chemicals, will increase in importance.

From the point of view of the national economy the introduction of such a new source of power is a clear gain. If it will lessen the cost of heat and power to our cities, it will be a stimulus to every industry. If it reduces the pall of winter smoke, it will be a boon to us all. If it gives cheap power where industry and agriculture need it but cannot now get it, it will extend our economic frontiers. These are possibilities that lie immediately before us.

Atomic energy is just one more step along the path of technological progress. It may, however, be the supreme gift of physical science to the modern age. Clearly its value will be determined by the use to which it is put. It is especially worthy of note that, along with other technical advances, the effect of atomic power is to force human society into new patterns. This need for human growth to meet the responsibility of atomic power is the basis of Norman Cousins' striking statement that "modern man is obsolete."

Let me note briefly three such effects of technology on society that can be clearly recognized. These are, first, toward greater *cooperation*, second, toward more *training and education*, and third, toward evaluating ones life in terms of *service* rendered to the community.

First, the society that is adapted for survival in the modern world is one in which an increasing degree of *cooperation* occurs between diverse groups spread over ever larger areas. As an example, consider the atomic bomb project, in which about a million people of all types and descriptions and spread throughout the nation worked together to gain a needed result that could be achieved only by a great coordinated community.

In no field is the growing importance of such cooperation more evident than in that of scientific research. Faraday, a century ago, was one of the first professional scientists. Work-

ing by himself, he covered the whole field of electricity and much more besides. Sixty years ago Thomas Edison organized what was perhaps the first research team to work with him at Menlo Park. Now our country has thousands of research laboratories. From 1900 to 1940 our universities developed organized research groups for studying specific problems. Astronomers built specialized observatories. Research centers grew for studying diseases. Teams of physicists built cyclotrons and surveyed cosmic rays over the world. When the war came cooperative research became of greatly increased size and effectiveness.

The development of the methods for producing plutonium is typical. At the peak there were engaged on this one problem roughly five thousand laboratory workers in more than seventy locations studying its different aspects. Not only theoretical physicists and nuclear chemists were needed. Equally vital were corrosion experts and metallurgists and haematologists and meteorologists, laboratory technicians, mechanics and office workers of many kinds. No one person could be skilled in every field or understand even the meaning of the answers to the many problems. But somehow the group mind integrates such knowledge into the useful form that results in a process that successfully produces plutonium.

There remains, happily, a valuable place for the individual research man who masters and advances his own limited field of study. His specialty, however, is of little value except as a part of a broader field. More and more we find that even in a limited field a team of men with different specialties working together does the most effective work. New thoughts develop in their discussions. More refined techniques are available. A team which thus supplies a combination of originality and special skills is the pattern toward which research is moving.

Cooperation is thus the very life blood of a society based on science and technology. Such a society is necessarily made up of specialists, not only scientists and engineers, but skilled laborers, salesmen, administrators, educators, and legislators. Working alone such specialists are useless. When their work is coordinated they form a society of enormous strength. It is

a major source of our nation's vitality that we have so many diverse elements in our population. Each has its place among the many specialties. What the society of an atomic age cannot permit is the development of antagonisms between these groups that will prevent effective cooperation. To love our neighbors is becoming the condition of survival And our neighbors with whom we work are to be found in all divisions of society throughout the entire world.

As the second evident effect of technology on society, consider the need for ever increasing *training and education.* It is because of the mechanical skill of many millions of workers, the know-how of our many technical men, and the administrative skill of our industrial and military leaders that our country has come out ahead in this war as in the last It is no disparagement of the American engineers who have done these great tasks to point out that most of the new wartime developments that have led to victory, such as radar, submarine detection, rockets, and the atomic bomb, have had to be led by men whose scientific knowledge is far in advance of that supplied by our technical schools and industries in the training of engineers. To compete in the modern world more people need more training. Nor is technical training all that is required. Of greater importance is more education for leadership. In a democratic society that is forced into a position of world prominence our citizens as well as our leaders need to understand the problems and human needs of all the nations.

This pressure for more training and education applies at all levels. Automatic machinery performs an increasing number of routine jobs. The demand for skilled mechanics to make the machines is thus increasing while that for unskilled labor falls off. The growing complexity of society multiplies rapidly the demand for all kinds of persons trained to keep the work coordinated. These range from typists to administrators. Of those whose over-all view of the needs of society is adequate to guide wisely an industry or the growth of a community there is an acute shortage.

The result is more students wanting more extensive education in schools and colleges. Professional schools are becoming

graduate schools. More research men will want to carry their studies beyond the doctor's thesis. The interruption of our college education during the war places our nation at a temporary disadvantage with regard to highly trained young men and women and is for the moment keeping down the enrollment in our advanced classes. All indications are, however, that the postwar pressure on our institutions of higher learning will increase and continue There is growing interest likewise in all aspects of adult education as our citizens strive to keep themselves abreast of the rapid changes of the times.

The third and perhaps the most remarkable trend is an increasing concern that one's activities shall *contribute to the welfare of society.* It is more difficult to establish this trend by citing examples than it is to show the increase of cooperation and of education. But it is, I believe, no less real. The ancient high regard for the "holy man" who retired to a monastery and separated himself from society finds little sympathy in our modern life. Reading of American colonial history shows that the freedom for which our forbears fought was primarily the right to live their own lives in the pursuit of happiness without unnecessary restrictions, not primarily the opportunity to shape a better society. Now both capital and labor strive to justify their position in terms of the usefulness of their contribution to society, and our nation has fought a war with unparalleled unanimity because our loyalty to the common cause made us ready for any sacrifice.

We have not had in this country prominent movements similar to that in Germany where the youth was whipped to patriotic ardor by the call to lose one's self in the greater good of the state. Nor has any "cause" in this country perhaps met with the wide response the Russians have given to communism as a political system in which each person consciously works for the good of all. Yet Americans respond to many calls to service. As members of scientific societies we are aware of our own increasing attention during the past generation to the social responsibilities of science and scientists. The present active concern of the scientists about the political disposition of the atomic energy problem is apparently only a representative ex-

ample of the anxiety of everyone in the nation that with the great issues with which humanity is faced his own actions may help rather than hinder a good solution. The greater powers placed in our hands by technology seem indeed to make us more acutely aware of our responsibility to use these powers for human ends that go beyond ourselves.

Typical of the forces working in this direction is recognized need that our form of society must attain its fullest strength if it is to survive in the fierce competition of the postwar world. We have come to realize however that our strength lies in the many millions of our citizens who are working efficiently and loyally at the nation's tasks. Widespread education, encouragement of each individual to seek for the place in the game where he can play best, opportunity for advancement and leadership—all these have helped to strengthen our society. Self-preservation demands that all possible effort be given to enable and encourage every citizen of the country to contribute his best to the needs of the nation. To attain this result, cultivation of the spirit of service is of first importance.

The evolutionary law of the survival of the fittest applies to societies as well as to individuals. According to this law the society of the future will inevitably advance along these lines of cooperativeness, of education, and of individual concern with service toward the common welfare. If selfish interests or an ill-adapted form of government should prevent our growth along these lines, some other nation or group that can develop thus more rapidly will pass us by.

You will note that these factors which give strength to society are precisely those that characterize the highest type of citizen. Cooperation: he likes to work with others on a common task. Education: he has learned to do his own useful task and to share intelligently in solving public problems. Service: the central objective of his life is to contribute to the common welfare the maximum that his abilities make possible. These also are the factors which make life of greatest value to the individual himself.

My point is this: the release of atomic energy is merely the most recent important step of that steady progression of science

that is compelling man to become human. He must pay careful attention to cooperation, education, and service for the welfare of society if he is to thrive under the conditions that science imposes. If we will let ourselves grow as thus indicated, the civilization of the atomic age promises to be the richest that history has known, not only with regard to material bounty, but also in its cultivation and appreciation of the truest human values.

How then are we justified in describing atomic energy as a human asset?

First, atomic energy now supplies for the first time weapons which make it possible for a centralized world government to prevent wars between nations. Having made war intolerable because of its enormous destructive power, it thus opens the way for an international organization to prevent war from ever occurring again.

Second, atomic energy is now a source of useful new materials produced by transmutation. It promises to supply us with heat and power available in large quantities wherever needed and thus to open new economic frontiers. New advances in medicine, in industry, and in science are on the horizon.

Third, as the most recent great step in the long progression of advances in science and technology, the advent of atomic energy is forcing mankind along the difficult road to greater humanity. Growing cooperation, education, and spirit of service are evident trends.

The present is thus a time for hope. True, the atomic bomb has brought us face to face with the fact that continued world strife will mean disaster and death. It is however likewise true, and much more worthy of attention, that the way is now open as never before for the world to reach a true unity, with world peace a necessity that can and will be attained.

When our first parents ate of the fruit of the tree of knowledge, they became as gods, knowing good from evil. Much as they longed to return to the garden of innocence an angel with a fiery sword stood in their way. Their only hope for peace lay in work to make the earth give them a fuller life. Somehow the marvel occurred that in their work they became human souls

who shared the task of their Creator and came to be called His children.

The same angel with the same fiery sword prevents us from returning to a pre-atomic age. We have no choice but to use our great new powers in the effort to build a better world.

In the fierce competition between social systems in the atomic age the need for strength demands that we enable every citizen to contribute to the common welfare as his abilities may permit. Permanent peace can now be secured if we will work for it. Increased prosperity with broader horizons lies before us. Greater development of the human spirit is the inevitable consequence of the increased responsibility for using our new powers. These are among the greatest of human goods.

FUTURE USES OF ATOMIC ENERGY [2]

The urgency of war problems left little time for the few scientists with sufficient knowledge of nuclear engineering to reflect about the future possibilities of nuclear energy. The exclusion of non-project scientists from technical information about atomic energy and the scientific details on which its development depends has made really original ideas about future applications —ideas which come from fresh viewpoints—remarkably scarce. Nevertheless, the field of usefulness of atomic energy is so enormous that even the applications which have already been thought about ("without trying," one might be tempted to say) change completely concepts of the possible and the impossible.

In short, atomic energy plants have possibilities of use which are essentially unique.

The characteristics of atomic energy units which give them these values are their compactness with large power capacity, and their economy of "fuel." They are known generally as "piles" because the first experimental one made was a pile of graphite and uranium stacked together a particular way.

Thus, a million-kilowatt electrical power plant need be no bigger than a big-city power substation, with the pile itself only a

[2] Atomic Scientists of Chicago. *The Atomic Bomb. Facts and Implications.* p. 29-40. 1946.

part of the whole. Compare this with the tremendous structures of Boulder Dam, Muscle Shoals or Grand Coulee, water-power units with roughly similar capacities.

An idea of the fuel economy of the pile as a power source may be obtained by comparing the bulk of a pound of uranium or plutonium with that of 1500 tons of coal, which gives, when burned, about the same amount of energy as the pound of uranium or plutonium does when consumed in the pile. Similarly, 250,000 gallons of fuel oil, or 40 million cubic feet of natural gas are also approximately equivalent to a pound of uranium. One pound of uranium or plutonium . . . is capable of yielding almost twelve million kilowatt-hours of energy, enough to supply the total power consumption of the United States for a quarter of an hour. An atomic power plant operating at the million-kilowatt level thus needs only about two pounds of uranium or plutonium a day, a good bit easier to transport than 3000 tons of coal.

Many rich areas lie relatively unused because of lack of fuel or power, and many wasteful procedures are part of our economy because raw materials are found far from their place of final use. The combination of virtues possessed by a pile—compactness, independence of natural watercourses, and relative freedom from supply problems—makes for possibilities which might have been dismissed as fanciful dreams.

With heat and power supplied by a pile, the rich Alaskan areas might be made liveable and highly productive. Ores need no longer be shipped long distances in their crude forms but their valuable constituents may be refined at the mines. Bauxite, for example, might be transformed into aluminum at the mine, avoiding the long and wasteful shipping from South America it now undergoes. Magnesium, now assuming importance as a structural light metal, can be manufactured at the seashore, as it is a major constituent of sea water. Many economies in transportation of both materials and electrical power might be effected by strategic location of atomic energy power plants.

In its present state of development, atomic energy does not compete with common fuels, but this need not be the case in the future. Consider the trainload upon trainload of coal which sup-

plies winter fuel for cities such as Minneapolis, Chicago, Pittsburgh, and many others. A central heating plant for each of these cities (a pile, whose energy would be used to warm air or form steam) would not only free transportation for other items, but would eliminate the characteristic winter atmosphere of coal smoke and soot. Furthermore, the coal so saved would be available for chemical use, to give synthetic gasoline, and to furnish the basic ingredients for the many plastics, fibers and other synthetic chemicals which are coming into use more and more.

After indicating some of the dazzling prospects opened up by atomic energy development, it is perhaps important to indicate those for which atomic energy (as exemplified in the uranium pile) cannot be used. The limitations depend primarily on certain physical characteristics of the unit. Here we need only point out that the pile is the source of very intense and very dangerous radiations, so that for the protection of those in the vicinity an encircling shield of many feet of concrete or other proper materials is essential. It is estimated that such a shield alone would weigh over fifty tons for the most compact sort of power system.

Another limitation is the fact that even though a very small amount of power may be desired, a large amount of material must be invested initially. This fact is related to the concept of "critical size." The minimum cost of materials for a power unit may well run into hundreds of thousands of dollars. It therefore becomes uneconomic to consider atomic energy units for low power uses such as, for example, the lighting, heating, and air-conditioning of individual dwellings.

In addition to the factor of economy, the factor of weight will rule out the use of atomic power for vehicles such as automobiles. A power unit as heavy and bulky as that indicated above would almost certainly also be out of the question for any airplane yet built, and its usefulness in driving railroad trains is equally problematical. A large ship might perhaps find the weight and size of a uranium or plutonium power plant within tolerable limits, but many factors would need to be weighed carefully before a decision to use piles as a motive force for ships were made. On the whole, therefore, the advent of atomic energy will not immediately revolutionize transportation.

It may, on the other hand, provide the key to space travel which has until recently been deemed completely fantastic. But it is true in this case as in all the others cited that progress will be made only when experts in diverse fields are allowed to speak freely with the atomic power experts. Continued maintenance of secrecy barriers stifles progress within the atomic energy field as well as without.

Tantalizing as the prospects of large-scale atomic power plants are, it may very well be that power will not be the most important product derived from the operation of atomic energy units ("piles"). The prospects of power are actually of less immediate importance than are the possibilities opened up through the production of radioactive substances even in small piles. In other words, piles will be useful and important for the production of radioactive substances and penetrating radiations even during the period in which power piles are not economically practical. Such radioactive substances have been made before, in minute amounts, by means of cyclotrons and similar apparatus, but the use of a pile will make possible the manufacture of tremendously larger amounts of such materials. While all the uses of radioactive substances cannot be foreseen at the present time, enough work was done before the war with the tiny amounts available then to point out the directions future work may take.

General Fields of Usefulness. Probably the most important uses of these new substances will be in the field of research—research in medicine and biology, in industrial processes, and in pure science. Developments in all of these fields will be greatly accelerated, for the availability of large amounts of radioactive substances will put into the hands of research men a new and most powerful tool—one which will make possible the gathering of knowledge unattainable by any other means. Radioactivity gives promise of being as important to medical and biological research as was the microscope, as important to chemical research as was the chemical balance, and as important to physical research as was the spectroscope.

In this new era of rapid scientific and technological development, the acceleration of all kinds of research means that advances in the well-being of man will be made more rapidly, that cures for

diseases will be discovered more rapidly, and that the new products and materials will be developed, which may give rise to great new industries comparable in size and importance to the synthetic rubber, the plastics, or the light metals industries.

From discoveries made before the war, it was already evident that radioactive substances will find direct use in medicine for the treatment of certain diseases, and that in industry they will enable many processes to be carried on more efficiently and economically.

Radiations and Substances Produced by a Pile. Thick concrete or steel shields are built around piles as protection against their intense gamma and neutron radiations, similar to those which injured and killed so many people in the atomic explosions at Hiroshima and Nagasaki. These radiations can be made available for controlled medical or industrial use through ports cut in the shielding. The radiation is emitted as a beam through these ports. Such use of these radiations is confined to the vicinity of the pile. It is an important extension of the usefulness of the pile that it can be used to manufacture other highly concentrated and portable sources of penetrating radiations.

These sources of radiation are radioactive materials formed in the pile, which are concentrated into a small bulk and which may then be shipped away in suitable containers. It is not possible to prepare portable sources which will emit gamma rays with the intensity of the pile itself, nor is it generally possible to prepare strong sources of neutrons. For most purposes, however, such concentrated, portable sources of beta and gamma rays as are available will be convenient and more than adequate.

Radioactive materials may be produced in the pile by two methods: (1) isolation of fission products, and (2) activation of foreign substances placed in the pile. If the desired radioactive element is one of the fission products, it may be secured by removing some of the uranium from the pile and separating the desired fission product by chemical procedures If the desired radioactive element is not one of the fission products, it can be prepared by putting a normal piece of that element into a thin walled tube which extends deep into the pile. Inside the pile it receives a tremendous bombardment with neutrons, and is thereby made radioactive. The radioactivity thus produced decays away

at the normal rate characteristic of that element, so that the radioactivity persists after the material is removed from the pile.

Uses of Radioactivity. The use of radioactivity falls into two categories: (1) the employment of the energetic and very penetrating radiations emitted by piles or radioactive elements, and (2) the use of the property of radioactivity as a "tag" for the atoms possessing it (the method of "radioactive indicators" or "radioactive tracers").

1. Use of Radiations: Industrial Uses. A number of uses are already known for sources of intense, highly-penetrating radiation Gamma-ray emitting radioactive materials may be used as cheap, portable sources of radiation for "X-raying" large pieces of metal and other opaque materials for the detection of flaws. They may be used in automatic regulators of various types, in which the radiations can be used to set off control mechanisms. High intensity radiations may have a great effect upon industrial chemistry. Just as sunlight bleaches many coloring materials, so many other chemical reactions—some of considerable importance industrially—can be made to take place when intense gamma-rays are used.

Medical and Biological Uses. Some types of medical treatment involve the irradiation of portions of the patient's body. Certain types of cancer, for example, yield to neutron irradiation, and others to gamma-ray irradiation. Either type of treatment can be given to many patients at the same time if a pile is available. Or gamma-ray emitting materials produced in the pile may be used instead of radium. Such materials will be cheap and plentiful where radium has been expensive and rare. Because of the wide variety of substances emitting gamma- and beta-rays, the substance used can be chosen to fit the particular case. For example, if a short, intense irradiation is desired, a radioactive substance of short life time may be introduced into the desired area. After a short time, it will have disappeared by radioactive disintegration.

Another method of using the radiations from radioactive substances in therapeutic work is by feeding or injecting them in a form which may be stored in the affected organs. Thus, radioactive phosphorous has been administered in the treatment of

leukemia, being concentrated in the blood-forming organs; and the concentration of radioactive iodine in the thyroid gland has been used to treat thyroid disease. Since strontium tends to be concentrated in the bones, it has been suggested that radioactive strontium can be used in the treatment of bone tumors. These are some of the procedures tried before the war; with the availability of large quantities of all kinds of radioactive materials, from radioactive phosphorous to radioactive arsenic, many more similar uses will be developed.

We must avoid assuming, however, that a universal cancer cure is just around the corner. Some tumors are actually more resistant to rays of all kinds than the normal body tissues, which must, of course, remain relatively undamaged during the treatment. Moreover, there is still no curative treatment for cancer which has become disseminated throughout the body. We are justified, however, in believing that many improvements in cancer treatment will follow the investigation of the use of new radioactive substances, just as experience and wisdom have constantly improved the results from the use of radium and X-rays.

2. Use of Radioactive Materials as "Tracer." A most important use of radioactive substances depends upon the fact that extremely sensitive instruments (e.g., "Geiger-Muller counters") are available for the detection of the radiations from radioactive materials. It is possible to detect the presence of very tiny amounts of these substances. For example, it is possible to detect a millionth part of a millionth of an ounce of radium. If radioactive material is added to non-radioactive material, it is possible to follow the mixture by using instruments to determine where the radioactivity has gone. For example, it is possible to follow the flow of gas through a complicated system of pipes and reactors, by adding a small amount of a radioactive gas and following the migration of the radioactivity with a "Geiger-Muller counter." This is an example of the simpler of the two types of uses for a "tracer," namely, following the bulk movement of a liquid, gas, or solid.

In the second type of application, radioactive tracers are used to follow a particular chemical component of a mixture. To take a specific example, if copper disappears from a solution as it flows

through a system of pipes, it is possible to determine where the copper is being lost. When a small amount of radioactive copper is added to the solution, this radioactive copper travels with the normal copper and is lost at the same place. This region can then be located by using a Geiger-Muller counter to detect the gamma rays emitted by the radioactive copper.

The use of such specific radioactive tracers depend upon the fact that all forms of an element have essentially the same chemical and physical properties. Thus, the element cobalt normally is composed of atoms called cobalt-59. When bombarded with neutrons, another form of this element is made, called cobalt-60, which is a radioactive substance. It has a life time measured in years, and disintegrates by emitting a beta-ray and a gamma-ray. The stable atom cobalt-59 and the radioactive atom cobalt-60, once they are mixed, will travel together through any kind of chemical reaction. Thus, the whereabouts of a large amount of ordinary cobalt (cobalt-59) may be followed by "tracing" a minute amount of cobalt-60 mixed with it.

Industrial Uses of Tracers. Radioactive tracers already have been used industrially to measure the flow of liquids and gases in the manner of the example given above. Thus petroleum engineers have used radium as a tracer to map oil pools. Radium mixed with oil is pumped down a well, and its distribution is measured by its radioactive properties. Because of the great sensitivity of methods for detecting radioactive materials, it is possible to find the radium even after it has become greatly diluted by being spread through a large pool.

Radioactive elements may greatly simplify chemical analysis problems in plant production work, such as the refining of steel. Very often it is necessary to hold up a process until a time-consuming chemical analysis has been made by the laboratory. If a tracer is introduced at the beginning of the process, it is possible to set up simple, quick, and often automatic analyses by radioactivity measurement which will eliminate the usual holdup. Such a process has been patented for following phosphorous in steel refining.

Hydrogen is one of the important elements composing petroleum. Radioactive hydrogen used as a tracer has already supplied

valuable information as to what goes on in the process of "cracking" petroleum, a process which produces high-quality gasoline and other valuable chemicals. It has been possible to find out a great deal about what occurs to the complicated molecules comprising petroleum during the cracking process, and such knowledge inevitably leads to improvements and new developments.

Chemical Research Uses of Tracers. The use of tracers in general scientific research will certainly expand tremendously as soon as the materials are available. The organic chemist, for example, is concerned with a vast number of compounds composed to a large extent of carbon and hydrogen. As mentioned before, a radioactive form of hydrogen is available; a radioactive carbon has also been made. With these two, the organic chemist may be able to determine just what happens to organic molecules when he heats them, or boils them, or causes them to react. With such knowledge, he can learn how to make them more easily, and more cheaply; and he can learn how to make more and more useful compounds. Considering that a very great portion of our chemical industry is based upon organic chemistry, basic advances in this field are sure to exert great influence. This is only a limited example of what the availability of radioactive tracers for all the elements can mean to chemical research.

Biological and Medical Uses of Tracers. One of the important uses of tracers in biology and medicine is to find out how the human body functions. It has been the experience of the past, that when such knowledge is available, methods of devising cures for diseases are greatly simplified. When bacteria could be identified under the microscope, the attack on bacterial diseases became much easier. The use of tracers made by cyclotron bombardment has already revolutionized much biological and medical research, because experiments may be attempted which are impossible without tracers.

Some of the uses of radioactive tracers are fairly obvious. Thus, the rate at which the blood flows through arteries and veins can easily be measured by injecting the tracer at one point and measuring the time which elapses before it arrives at the point where the detecting device is placed. In a similar fashion, the rate at which sap rises in plants may be found directly.

The concentration of a substance in a certain part of the body can be directly demonstrated. The accumulation of iodine in the thyroid can be shown by placing a counter on the neck after radioactive iodine is administered. This method has been used to study the nature of various diseases of the thyroid, in which the gland may be avid for iodine, or may refuse to store it. It is also possible to determine, by injecting a very small amount of radioactive iodine into a patient with thyroid cancer, whether it is worth while to treat the patient with a much larger amount, or whether operation is called for.

These and similar uses of radioactive tracers hardly scratch the surface of the possibilities. Minute, non-poisonous amounts of drugs, vitamins, and poisons can be followed around in the body by the radioactive tracer method, because of the great detection sensitivity. "Tagged" drugs will shed new light on the site and mode of action of therapeutic agents (such as the "sulfa" drugs and penicillin) and allow a totally new approach to medication. Moreover, the greatest value of this method lies in what it can tell us about those normal body processes whose investigation defies ordinary chemical methods.

We know, for instance, that the body continually requires food, that a great variety of foods must be eaten, and that some are "burned" in the body and produce heat. We have found out, by very difficult and painstaking experiments, the identity of a great many of the chemical compounds which are formed in the body from the food originally taken in. If we analyze an organ at two different times, the analysis often does not show any appreciable change, so that it is usually impossible to tell what has been happening between these two analyses All of the subtle vital processes can be studied relatively easily and in great detail by using tracers, for we can make one of the normal body compounds in a radioactive form, administer it, and then follow the complete history of the "labelled" molecules. The course of phosphorus in the body has been traced in great detail in this fashion.

This method has already shown that many of the structures of the body, which had always been considered to be stable, are really changing, breaking down and rebuilding, at great rates of

speed. These changes can now be watched, and it is fair to say that the method gives us a wholly new conception of body and cell processes. Such a revision of our basic ideas leads in turn to changed interpretations of health and disease, greatly affecting medical practice.

In plant biology, the tracer method has already shown itself to be of great importance. One of the most puzzling and important problems of science is "How do plants manufacture sugar out of carbon dioxide, water, and sunlight?" If man could duplicate this process of "photosynthesis," first in the laboratory and then on an industrial scale, the bountifulness of the earth might be greatly multiplied The world's fuel and food supplies would be assured as long as the sun continues to emit light. A most powerful tool at the disposal of the chemist and biologist for understanding, and perhaps eventually duplicating photosynthesis, is the tracer, radioactive carbon, which has been mentioned before. If, as a result of our greatly increased production of radioactive carbon, the riddle of photosynthesis is solved, that, and not power plants or atomic bombs, will stand as the greatest achievement of atomic energy release.

Summary. The most significant uses of artificial radioactive materials will be in laboratory researches in which the tagging of atoms through their radiations will enable technical advances to be made whose very nature cannot be predicted at this time. Just as the experiments of Fermi in 1934 led, all unexpectedly, to the production of the atomic bomb and other atomic energy sources in 1945, so the final results of such "tracer" researches and their influence on life even a few years from now cannot be adequately anticipated. But the effect will be great. A necessary condition for obtaining these benefits, however, is an enlightened attitude towards the control and release of radioactive materials and information concerning the methods for using them.

For the purposes of manufacturing radioactive materials or for using pile radiations, it is not necessary to have piles which can supply industrial power. Piles incapable of delivering useful power can still supply adequate amounts of radioactive materials to all users and can also serve as strong sources of gamma and neutron radiation. In order to simplify the problem of interna-

tional control of atomic weapons, it may be considered necessary to delay for a time the use of atomic power on a large scale since the power installations may be used to form quantities of fissionable material which could be used in bombs. Even if this postponement occurs, it will not be necessary to delay at all the great benefits derivable from the use of radioactive materials.

THE IMPACT OF NUCLEONICS ON MEDICINE[3]

According to the newspapers and the reports of the scientists who viewed the destruction at Hiroshima and Nagasaki, many Japanese were damaged by radiations released at the time of the explosion of the atomic bombs. Some died immediately and others over a period of weeks. In the case of the latter, their hair fell out, they developed diarrhea, bled from various surfaces, developed ulcerated throats, had their blood cells destroyed, and in other ways resembled experimental animals whose bodies had been exposed to lethal doses of various kinds of radiations. The radioactive fission products, on the other hand, apparently nearly all went up in the overheated cloud and were diluted in the upper atmosphere. It is clear that just as people died from and were injured by pressure waves and heat waves, so they died from and were injured by radiation waves at the time of the bomb explosion. Fortunately or otherwise, as you care to view it, the tremendous radioactivity of the fission products themselves was wasted by going off in the cloud. Had the bomb exploded nearer the ground, conditions might have been different.

So much for the destructive aspect. Surely the atomic age has a constructive aspect for medicine. What do we mean by the atomic age? As now used, the atomic age is synonymous with atomic bombs and started on July 16, 1945, at Alamogordo. Atomic bombs offer medicine nothing unless it be an increase in the desire to learn how to treat people who may be

[3] By Robert S. Stone, M.D., Professor of Radiology, University of California; in charge of medical research in atomic energy development. *Chemical and Engineering News* 24.482-5. February 25, 1946. Also published in *Chemistry*. 19 18-22 January 1946.

overexposed to radiations. Most people really mean the age of atomic power—power obtained from nuclear chain reactions. That age started on December 2, 1942, when the first chain-reacting unit became a reality. Several controlled chain-reacting units have been built since then and it is obvious that they can provide the following:

1. An abundant supply of the particular radioactive isotopes formed in the fission process.
2. A supply of such other radio-elements as can be made by bombardment with neutrons of the energies available.
3. A source of slow neutrons.
4. A source of fast neutrons.

All these were available before chain-reacting piles came into existence but in quantities so small as to be very limited in distribution and usefulness.

While trying to anticipate what these tools are going to mean to biology and medicine in the future, it is well to remember that the usefulness of the discharge of electric currents through rarefied gases and vacuum tubes was at one time a pure research problem where knowledge was sought for the sake of knowledge. Not one of the early experimenters even thought of the Roentgen ray. Even after Roentgen had discovered the X-ray, many people thought of it as a tool which would be useful for locating fractures. I do not mean to imply that the use of radioactive materials and neutrons will, of necessity, create such a change in our medical procedures as have X-rays, but I firmly believe that there is a definite probability that such will be the case.

The use of artificial radioactive materials for research in medicine and biology is probably the field in which it is easiest to see the usefulness of the new tools. Many radioactive isotopes were available from cyclotrons before the war, but the limited quantities controlled the type of research done and the number of people who could obtain and work with them. The conservatism of the medical profession in adopting new tools, the same conservatism that was slow in using clinical thermometers, stethoscopes, and antiseptic techniques, has also played its part here.

Radioactive phosphorus and the nonradioactive isotopes of nitrogen, carbon, oxygen, and hydrogen have already been used with conspicuous success in determining the mechanism of many complex steps in metabolism. They have thrown considerable light on how single atoms are exchanged in living material for other atoms, even in such apparently permanent structures as teeth and bones. The use of radioactive carbon in studies of plant and animal metabolism offers the greatest possibility of advance in the understanding of life processes. Carbon is desired because of its long half-life. The use of very short-lived carbon isotopes has already radically changed the knowledge of photosynthesis. Using piles, carbon can be made in much greater quantities than before and with this isotope, the processes of photosynthesis can be further elucidated. No life at all would be possible on earth if we did not have plant life to synthesize organic matter from the nonorganic materials of carbon dioxide and water. Just what significance the understanding of this process will have cannot be foretold. In animal life very little is known about the mechanism of fundamental processes. Many of these will undoubtedly become clearer when we can trace the "tagged" radioactive atoms of carbon.

The use of nitrogen and sulfur in the study of protein metabolism offers possibilities of great significance. Phosphorus, strontium, and iron have already been used to good advantage and their field can be greatly expanded. There are numerous elements in the body which are required in very small amounts and whose exact usefulness is not clearly understood. Some of these, such as boron, manganese, cobalt, etc., can be investigated better with radioactive isotopes. It is reported that the sheep in New Zealand died for lack of cobalt, and yet the role that cobalt plays in metabolism is unknown. Copper is known to be an important, if small, ingredient in the human body and yet its function is not clearly understood. Radio-copper can probably be of great value in this study.

The use of radioactive materials in pharmacology offers a very wide field for expansion. It should be possible to follow, as has been done in a few instances, the course of drugs and thereby gain a better insight into why and how they act.

The use of radio-elements in the field of therapy is one that still requires a large amount of work. The place of radio-phosphorus in the treatment of leukemia is well established, but with larger quantities available, a larger number of patients can be treated by different physicians using various techniques of administration. The use of radio-strontium in the treatment of metastatic carcinoma in bone and for other diseases can now be tried in a much larger field than was ever possible before. Radio-iodine, which has already proved its usefulness in certain cases of hyperthyroidism, can now be used in much greater quantities. These are the obvious problems which need immediate attention. There are surely many more which are not apparent now but will come to the forefront as the work in this general field progresses.

One of the hopes for the future is that some chemical may be found which will lodge in cancer cells, at least in much greater concentration than in any other type of cells. If such chemical is not by itself able to kill the cancer, then a radio-element may be attached to it and thus a more effective means of treating cancer may be developed than anything known before. The effectiveness of this would lie in the fact that the distant metastases, as well as the primary lesion, would be attacked.

Another field in which radioactive materials from the pile can be used is that of substituting for radium. Elements such as tantalum and cobalt can be placed in the pile and made radioactive in such a way that they give off gamma-rays of high energy. By this means, it will be possible to make treatment bombs that will contain hundreds of curies rather than our present small bombs of two to ten curies of radium. Whether such methods will offer any advantage over the 1,000,000- to 20,000,000- or 100,000,000-volt X-ray machines, which are possible now because of developments of transformers, tubes, and betatrons, remains to be seen. There is also the possibility that needles could be made of tantalum and kept activated in a pile until desired for use. For interstitial therapy, these could replace radium, but since the activity remains in them much longer than in radon, they could not replace that gas. However, radiations of various penetrations will be available from different radio-

elements so that those therapists who wish to use such varying energies will have them available for any use they care to make of them.

The use of radioactive materials in diagnostic procedures in medicine will expand as these materials become more available. The uptake of radio-iodine by the thyroid gland has been shown to be characteristic in various types of pathological conditions of that gland. More recently the usefulness of radiosodium has been established in diagnosing the extent of defective circulation in the extremities in such conditions as immersion foot, arteriosclerosis, and thromboangitis obliterans. Many new procedures will undoubtedly follow in great profusion when the radioactive elements become available.

Fast neutrons have been used for the treatment of human malignancies since 1938 and some experimental biological work was done before as well as since that time. Two hundred and twenty-eight patients with presumably incurable cancer were accepted for treatment between September 1939 and February 1943. Twenty-six of these were still alive in June 1945. These inconclusive statistics, coupled with clinical experience, indicate that neutron therapy has been of value but since it has been used under the direction of only one radiologist and no single technique was given a fair trial, it is desirable that fast neutron therapy be further investigated. Data obtained by the physicists indicate that more penetrating neutrons than those already used will be needed to treat effectively deep-seated cancer. The fastest neutrons available from the pile are still in all probability not penetrating enough to be of value for treating any except superficial lesions We will still be dependent upon cyclotrons for more penetrating neutrons.

Just what therapeutic value slow neutrons will have is not yet clear. One method of using them was suggested a few years ago. The element boron captures slow neutrons and immediately emits an alpha-particle which produces dense ionization for a very short distance. If boron could be made to localize in tumors and the individual with the tumor then placed in a beam of slow neutrons, possibly even the small number of neutrons that penetrate to the necessary depth in the body would cause suf-

ficient disruption of the cancer cells to kill them. Such possibilities deserve further investigation.

It is apparent that the age of using nuclear energy was already here and being used by the medical profession before a chain-reacting pile was started. The study of nuclear changes started when Becquerel, stimulated by the work of Roentgen, discovered that it was not the induced fluorescence but the naturally occurring rays from uranium that caused changes in photographic plates. The discovery of radium by the Curies provided the first source of nuclear energy for medical and biological uses. The discovery of the phenomena of artificial radioactivity widened the field and the discovery of the cyclotron was a great stimulus to its advance. Now atomic power machines, by which is meant those machines utilizing the energy from fission, have again increased tremendously the possibilities for the useful applications to medical research and therapy of radioactive isotopes and neutron rays.

From a continuous stream of scientific development, which in 1895 centered in Roentgen and in 1945 in atomic power, have come numerous side streams that have proved of extreme value to biology and medicine. Those who have taken part in all of this research have usually been limited to narrow and restricted fields because the minds of most men are limited in scope so that they can encompass only a small portion of any field. The development of each separate portion has required specialization both as to the broad fields of science and as to the narrower subdivisions. It has been necessary to have physicists like Roentgen and Compton to interpret the physical aspect of radiations, and radiologists to adapt these to medicine.

The various products of nucleonics are certain to cause great changes in the field of medicine. The use of the radioactive elements and of external radiations in therapy is obvious, but rapid advances in the cure of cancer and other diseases are not to be expected. X-rays and radium have already been used to great advantage in this field. "Tagged" radioactive elements as diagnostic aids are slowly but surely becoming more useful. The field where the greatest advance appears possible is in the

use of radioelements to obtain a better understanding of the process of life in both the plant and animal kingdoms.

WAR'S GIFT TO PEACE [4]

A large amount of space in our daily papers and periodicals has been devoted to glowing accounts of the painstaking, involved research by world famous nuclear physicists culminating in the splitting of the uranium atom. Interesting speculations on the possibilities and availability of atomic power have been indulged in but all too little has been said about the benefits which industry, as it is today, might expect, not from the use of atomic power, but from engineering principles, new equipment and new methods developed as a necessary prerequisite of the atomic bomb.

It is therefore the purpose of this memorandum to make available some tangible assets accruing to American industry right now from knowledge gained in the successful solution of the problems faced in separating U-235 from natural uranium by gaseous diffusion methods. . . . The development work for this method had to be transformed from a highly theoretical concept without even a laboratory process upon which to base design and performance data into an efficient, multi-stage, commercial, gas recycling process. And it all had to be done in a hurry. So vast was the undertaking and so enormous the cost that it is quite safe to state that no single corporation or group of corporations would even consider industrial research on this subject with such little prospect of success. The saying "necessity is the mother of invention" was never so true as in the new developments, both in apparatus and process, conceived, developed and applied under the emergency of war to bring the project to a successful conclusion.

It is doubtful if such concentrated research was ever before brought to bear on any one problem. That it was solved quickly is a tribute to the ingenuity and resourcefulness of American sci-

[4] Memorandum issued at luncheon of the M. W. Kellogg Company and its subsidiary, the Kellex Corporation, New York, September 17, 1945. 10p. mim.

ence and engineering and bodes well for future developments in this field. The total cost of just separating the U-235 isotope by the diffusion process in important volume reached a substantial portion of the over-all figure of $2,000,000,000. Mistakes were made of course because decisions had to be made quickly, but progress is not achieved without mistakes. The important point is that these mistakes were capitalized on, and now that it is all over, the vast sum of money spent can be considered not only as a necessary war expenditure or as a preliminary to developing super-power resources in the future, but also as our government's contribution toward the betterment of industry as a whole.

For there is no doubt about it, industry does not have to wait for atomic power to utilize the experience of the project. Many lessons have been learned which can and will be applied to more efficient processing immediately. It can not all be revealed in print at present but it is in the minds of engineers and firms participating in the project and will be inextricably bound up with their future thinking, engineering design, construction and processing. Some items in these fields can be mentioned and are considered below. It is hoped that they will afford to the serious thinker some idea of the enormity of the problem and the scope of its application toward the betterment of our industries.

Following are some of the industries with indications of how they will benefit from knowledge gained in the U-235 problem:

1. *Petroleum refining.* (a) improved pumping; (b) new type, more efficient heat exchangers; (c) mass spectroscope (continuous analytical control); (d) possible new methods of separating gasoline fractions; (e) improved automatic control.

2. *General chemical and processing industries.* Same as in petroleum refining.

3. *Manufacture of pressure and vacuum vessels.* (a) checking welds, (b) pretesting vessels for leaks before operation; (c) improved vacuum techniques.

4. *High vacuum industries.* (a) improved vacuum methods for vitamin distillation; (b) new methods of detecting

high vacua in electronic tube manufacture; (c) low pressure, low temperature dehydration of foodstuffs.

5. *Gas processing industries.* (a) diffusional separation of helium from natural gas; (b) efficient separation of hydrogen from process gases; (c) diffusional separation of oxygen and rare gases from air; (d) new techniques in gas recycling.

6. *Electrical industry.* (a) new electronic techniques in high vacua; (b) improved micro-sensitive instrumentation.

7. *Medical profession.* (a) a low cost, more abundant source of radioactivity; (b) improved protective methods for combatting toxicity in industry; (c) extension of cancer therapy.

8. *Refrigeration industry.* (a) increased safety in equipment; (b) improved handling of fluorides for refrigerants.

9. *Industries employing corrosive chemicals.* (a) new pump and valve lubricants and packing methods; (b) new treatment of metal surfaces to prevent corrosion; (c) improved safety practices; (d) completely enclosed pumps operated from exterior by induction.

Right from the start of the project staggering obstacles loomed. Uranium, being a solid had first to be transformed into a gas for utility in the selected gas diffusion process. This meant selecting a compound of uranium with some other element which would be gaseous at nominal temperatures and from which elemental uranium could be readily regained after diffusion. After much experimentation, which included uranium hexafluoride, UF_6, and also other gases, suitable process gases were selected. One of the big advantages of UF_6, which brought it into special consideration was that fluorine, having only one isotope, would not complicate the separation by adding new combinations which would diffuse at varying speeds. Uranium hexafluoride is a solid at room temperature but fortunately turns into a gas at 56°C. Unfortunately, however, like most fluorine compounds, it was highly reactive, physiologically poisonous, and introduced problems of corrosion which pointed toward difficulties in production and handling In the words of one Kellex spokesman "uranium hexafluoride is one of the hardest things to handle in the history of mankind."

It was found that practically all the techniques and developments gained in the successful study of the problem could be carried over into a number of industries plagued by corrosion factors through improvement in equipment and processing. The results indicated a saving of millions of dollars annually in the conservation of critical equipment and materials, minimum breakdown of moving parts and also increased safety for workers.

In the process it was imperative that no material in contact with the process gas react with it since such corrosion would lead not only to plugging of the microscopic pores of the diffusion barrier and various mechanical failures but also to absorption (i. e. virtual disappearance) of enriched U-235 isotope. Obviously, therefore, standard type valves and piping could not be used; instead, new methods of pretreating metal surfaces against corrosion were worked out, new coolants, piping, new type heat exchangers, lubricants, pumps and packing were developed to satisfy the stringent requirements.

Hydrogen fluoride is an important isomerization and alkylation catalyst in petroleum refining as well as an important raw material in the production of aluminum and refrigerants. It is, however, so highly active and dangerous that industry has not yet capitalized on many of its potentialities. Its handling may now be made safer and simpler without excessive maintenance costs and as a result its increased use in industry may be realized.

Other important starting materials for a host of industrial products such as sulfur dioxide, hydrogen chloride and the mineral acids (sulfuric, nitric and phosphoric) have all presented severe problems of transfer and corrosion with particular emphasis on valve lubricants and pump packings. These difficulties can be greatly simplified by application of the knowledge gained through the extensive experimentation with UF_6 and the other related gases.

The story on pumps, the heart of the process and one of its most difficult problems, is particularly interesting and applicable to modern industry. Thousands of pumps operating under reduced pressure at Oak Ridge created problems in vacuum technique on an unheard of scale. Other thousands operated at nominal pressures. But regardless of the type or service none

could leak or corrode and all had to have as small a volume as possible. Many different types of centrifugal blower pumps and sylphon-sealed reciprocating pumps were tried out and new types developed For example, in one of the pumps for the larger stages the impeller was driven through a coupling containing a very novel and ingenious new seal. Another type of pump was completely enclosed, its centrifugal impeller and rotor being run from the outside by induction.

Top flight pump designers from leading manufacturers in this country collaborated in research at the central Kellex laboratories in Jersey City and succeeded to a remarkable degree in increasing industry's knowledge of this all-important phase of processing. For security reasons the practical applications of the new types of pumps developed can not yet be revealed publicly. However, the engineers who participated in this phase of the project have brought to their parent companies a vastly increased lore of new techniques which cannot help but be reflected in increased service to their customers.

Perhaps the most significant advance in pump design which has been most successfully accomplished is the utilization of supersonic velocities of a very high order (Mach numbers of over 1.0).

Literally acres of porous barriers were required for the gas diffusion plant with billions of holes smaller than 0.01 micron (about two millionths of an inch). Despite the high degree of porosity required such barriers had to be able to withstand a pressure head of one atmosphere The pores had to be of uniform size and spacing, must not become enlarged or plugged up as the result of direct corrosion or dust coming from corrosion elsewhere in the system, and the barriers had to be amenable to manufacture in large quantities and with uniform quality.

One of the major reasons for the lack of diffusion techniques in industry today has been the barrier problem. Few, if any, corporations cared to expend the prohibitive time and money in the necessary research on this problem, until it was made necessary by the exigency of the situation. Almost at the last minute an excellent barrier was developed and today these operate successfully throughout the more than several thousand stages.

Now that a large part of the basic research on diffusion barriers and their application to full scale industrial separations has been completed, particularly with reference to gas recycling and instrumentation, it seems almost certain that helium will be separated from natural gas by diffusion techniques rather than by the present refrigeration method Helium is so light in comparison to other components of natural gas that its diffusion velocity through a porous barrier is over twice as great as the next lightest compound present in the same source.

It may be even easier to isolate hydrogen by these new methods from a number of process gases now used merely as fuel because the diffusion velocity of hydrogen, the lightest of our elements, is over four times that of any compound associated with it.

The isolation of ethylene from cracked gas oil by incorporating diffusion barriers as an integral part of cracking units could conceivably supply an abundant source of this versatile chemical used for the manufacture of synthetic rubber, plastics, antifreeze, alcohol and many other products.

The preparation of oxygen and rare gases from air without resorting to refrigeration and fractional distillation is another possible application, when economic methods are developed.

The direct isolation of natural gasoline fractions from crude petroleum without resorting to distillation, and new types of fractionating columns for the petroleum refining industry also appear feasible.

If pumping is the heart of processing, then instrumentation is the brain. No continuous process could function efficiently without adequate automatic control. In the gaseous diffusion plant the problems of instrumentation were far greater than in any other industry because the theory involved the assumption that diffusion took place through an infinite number of stages whereas practicability dictated that such stages be limited in number.

Even so, several thousand stages were required, necessitating an intricate system of gas recycling involving abnormally large volumes of gases in relation to the finished product and continuous high precision analytical control About half of the gas processed in each stage diffused through the porous barrier as

enriched U-235 product, and after repressuring was sent on to the next higher stage for further concentration; the impoverished half was also repressured and recycled through the next lower stage. The recycling involved was enormous, over 100,000 times the volume of the final enriched gas.

There were developed to meet these needs the most precise, continuous, automatic, analytical control instruments ever produced by man. This refinement is one of the outstanding features of the gas diffusion plant and constitutes one of its most important applications to industry today. Instruments which before had existed only in research laboratories were improved upon and adapted to commercial use; completely new prototypes were conceived, developed and put into mass production. The result is that now as never before there is available to industry a more nearly perfect system of continuous automatic control than has ever existed.

One of the developments employed is a new type of mass spectroscope which every petroleum refiner will welcome for control of cracking operations and transfer line analysis. The mass spectroscope has been employed for several years in research laboratories and even within the last two years in certain phases of the refining industry but never on the perfected scale developed at Oak Ridge. The foremost instrument engineers and physicists in this country and England devoted their full time not only toward gearing this instrument to continuous control but also to expanding this country's capacity for its quantity output. In no other country has electronic research been applied on so grand a scale. Security considerations are not violated in revealing that the mass spectroscope is an electronic device for analyzing gases both qualitatively and quantitatively from a mass standpoint by separating a beam of dissimilar gas molecules into separate beams according to their formula weight. Determinations are very fast, require only a thimbleful of gas and make obsolete the formerly used Orsat and chemical analyses particularly for the purposes of continuous control where instantaneous changes must be effected the moment a process swings "off the line".

Its potential uses in industry include the accurate analysis of natural gas or any process gas, the continuous automatic control

of any gaseous process such as alkylation, dehydrogenation, vapor phase cracking, etc., the checking of inert gases such as nitrogen used to provide a protective atmosphere in furnaces etc., the checking of the completeness of any evacuation process as in the manufacture of radio tubes, the detection of impurities, and many others. Industry will not have to wait for benefits from this versatile tool because production facilities have been enormously increased since the new type was created.

A second development, aptly and simply called "the leak detector" is more sensitive than any other existing device previously utilized for the same purpose. It played an important part in ensuring that all parts of the gaseous diffusion plant were vacuum tight. Any leaks out of or into the system would be damaging both from the standpoint of loss and contamination of an exceedingly valuable material. The leak detector is well adapted for locating annoying leaks in industrial high vacuum processing industries such as vitamin manufacture where even microscopic leaks undetectable by the familiar ammonia-hydrogen chloride method or Tesla Coil method are still potent enough to prevent drawing the necessary high vacuum on the equipment. Other potential uses include the pretesting of pressure and vacuum apparatus before putting it in service, checking equipment in operation to ensure no wasteful loss or contamination, the testing of welds for minute pores which would otherwise escape detection and ensuring the physiological safety of refrigeration equipment employing toxic coolants.

Of great interest to the petroleum refining industry is the development of a new type heat exchanger. Since an unavoidable concomitant to pumping gas is heating it and since enormous volumes of gas were processed, individual cooling units for each stage had to be developed. A brand new type of heat exchanger was conceived for this purpose and developed up to the production stage. A manufacturer was then selected, shown how to make it even to the extent of redesigning his equipment so that thousands of units could be turned out quickly. They were installed and functioned very well.

Thanks to the variety and multiplicity of radioactive products which can be produced by means of U-235, we face the prospect

of soon having available for therapeutic medicine radioactive materials possessing a wide variety of properties. It is logical to expect, therefore, that these new materials will be suitable for products offering a greater range of usefulness, and at lower cost than radium.

The possibility exists of incorporating a micro quantity of a radioactive isotope in food to observe its metabolism in the body of experimental animals. Such "tagged" material could be readily traced in its passage through the organs of the body.

It should be borne in mind that the benefits mentioned above accruing to American industries as a result of knowledge gained in the development of the gas diffusion plant represent only a small part of what is permitted to be revealed at this time. The total cost of the project, $2,000,000,000, actually only represented eight days of war cost to the United States.

If it be estimated that the war would have lasted another six months the actual saving could be estimated at $45,000,000,000.

BRINGING THE ATOM DOWN TO EARTH [5]

There were three atom bombs and four explosions: New Mexico, Hiroshima, Nagasaki and, the fourth and most shattering of all, the blast that plummeted the minds of untold millions into the strange new world of atomic energy.

The fact is that the dreaded but alluring atomic age is already here. Whole nations have grasped that fact almost with the speed of light. They may cringe before it—but they want it for its advantages and in spite of its dangers.

What does it portend for the future? Is a breath-taking revolution—industrial, social and even political—at hand? Has a new starting point in history arrived? Are science and invention, in unleashing unlimited power, about to turn the world upside down? Here's a prediction:

Within five years the first harnessing of the atom for peace will have been achieved, and within ten years it will be the useful servant of man in a score of different ways.

[5] By William F. McDermott, writer for various periodicals. *Popular Mechanics Magazine*. 84:1-6+. November 1945.

Before we do any crystal-gazing, however, let's look at what some of the world's greatest thinkers and scientists, including several who were in on the miracle of the atom bomb, have ventured to foresee about man's capture of this secret of the universe:

1894. H. G. Wells predicted world-wide use of atomic energy and the employment of atom bombs by 1954, saying that civilization would either destroy itself or adapt itself to a life as different as that of another planet.

1905. Einstein, declaring matter to be highly concentrated energy, calculated that 10 billion kilowatt-hours of energy are locked up in a pound of matter.

1926. Prof. James F. Morris, Massachusetts Institute of Technology, asserted that matter consists of "unthinkable amounts of bound-up energy," while Dr. Karl Schlessel, German scientist, forecast: "The time is not far distant when, with the liberation of the atom, man will forget there ever was such a thing as suffering or poverty."

1939. Dr. Arthur H. Compton, Nobel Prize winner, addressing the Association for the Advancement of Science, said that atomic power, long-sought goal of science, was nearer man's practical use than was even dreamed of a year before. This power, locked in the nucleus of the atom, is of such tremendous order that a minute quantity of it would be sufficient to transport a liner across the ocean or to fire a gun from Chicago to Berlin.

1940 Dr. R. M. Langer, California Institute of Technology, one of the leading scientists in the development of the atom bomb, predicted that atomic energy would "change the face of the earth," with Sunday driving in a propellerless plane fifty miles above the ground, with free power for everyone for all possible uses and with unimaginable convenience for everyone's pleasure.

Even before Pearl Harbor, the curtain was quietly drawn on atomic developments, but the most feverish experimentation in all history swung into full speed. Four years later, that curtain was literally torn to pieces with the crash of the bomb on Hiroshima. The unleashed power not only met every expectation, but seemed to give prophetic promise of the fulfillment of every amazing chronicle of what the release of atomic energy might mean to the future of mankind.

Cautious scientists, whose secrecy for years had equalled their applied genius—both complete—lifted the veil for a peek into the future. They who had worked closest to the atom bomb foresaw near-miracles to come. One of the most effective projections into the future was made by Dr. Reuben G. Gustavson, eminent scientist and dean of faculties of the University of Chicago, whose work on the atom bomb was of major importance.

Energy 400,000,000 times more powerful than derived from any other power source can be delivered, he told the Executives Club in Chicago. And just as important as that was his assertion that, if resources were made available, an experimental atomic plant could be placed in operation by next April, and in five or ten years production of such power could be made economical! He added that atomic developments may bring about the long-sought cure for cancer.

The logical first step will be to capitalize on the knowledge of the atom bomb—namely, apply the known controlled form of atomic power. That is as a superexplosive. Where could constructive use be made of such devastation as was visited on the two Japanese cities, laying waste many square miles at a single blow, and leveling as many as 18,000 buildings?

One of the likeliest effective services would be in checking forest fires. Even as enemy cities were being blown to pieces, a great conflagration ravaged more than a quarter of a million acres of fine timber in Oregon. Fire fighters struggled in vain to make clearings beyond which the onrushing flames could not go—yet a path a quarter of a mile wide in advance of the blaze, such as controlled, minute atom bombs might blast in a single second, would have done what thousands of men couldn't do.

Already there is speculation as to the possibility of some weather control by atomic forces. The mayor of a Florida city asked that a bomb be exploded in the midst of a hurricane, to see if it might scatter or check it. That raises the question whether something akin to a vast tidal wave might be started whose destructiveness would be still greater. It is believed, however, that the atom bomb does affect the weather. Although the sun was shining brightly when the atom bomb was dropped on Hiroshima, a missionary reported that a hurricane struck the city half

an hour after the bombing. In another case a storm cleared away soon after a bomb was exploded.

A tremendous iceberg sank the Titanic, luxurious liner which was the pride of all the seas in its day, back in 1912. Even today icebergs are a menace to navigation, and their presence must be taken into account in charting the courses of vessels. Atom bombs, or well placed atomic explosive charges, offer the possibility of clearing the oceans of these floating dangers. Broken into icy slivers, they might dissolve in the warmer water and disappear. The terriffic heat engendered by an atom bomb, shown by the way sand was fused into slabs in the New Mexico experiment, indicates that heat as well as violence would aid in vaporizing the icebergs.

Icebergs do not form the only frozen barriers of the sea to man. Vast expanses of ice tie up harbors often for six months or more of every year. Russia is an example of a great nation virtually ice locked half the time because her ports are so far north. She may get year-round ports as the result of this war.

The question arises: Does not atomic power make possible keeping open those icebound ports the whole year round by recurring blasts, or at least opening ports weeks sooner than usual and keeping them open weeks longer? The use of heavy ice-breaking boats may give way before long to a string of atomic explosions that will make a winter path for ships as clear as in summer time.

Sea power was shown in this war to be as effective as ever in the history of the nations. While air power is a new and major factor, yet it has neither eliminated nor minimized seagoing traffic; also, with "one world" at hand—at least in trade and commerce—there is bound to be undreamed-of traffic on the seven seas. Now, if ocean floors could give up their dead—sunken ships—there would be a parade of watery ghosts which would probably stretch farther than the merchant marines of the world today, and many of them would be found to have been the victims of hidden rocks and treacherous shoals.

Here the tumultous power of the atom may soon come into play. Explosions that level cities can also lay waste many a granite "hell gate" where ships totter into watery grave. With

the limited power we now have at hand we clear the channels of rivers of snags and hazards and we take out of harbors the natural menaces to traffic. Now with atomic explosive power, there is every reason to believe we will move out and conquer similar major dangers of the high seas.

That isn't all As we may clear old channels, we may well make new ones. Remember reading how the French spent decades in trying to dig the Panama Canal and then failed? We took modern machinery and modern science (primarily to conquer yellow fever and malaria) and did it. At that, it required years of arduous toil. With atomic power controlled, as it will be just as other natural forces have been harnessed, a new Panama Canal is possible in weeks instead of years. One foresees such a channel charted, with calculations showing the exact amount of explosive power needed to remove rock or soil; then tiny holes dug, and a string of atomic pellets buried along the right-of-way. The switch is thrown—a deafening roar and clouds of dust and smoke follow When they clear away, the rough channel lies before you, the major job done. Significantly, the atom-bomb explosions in New Mexico and Japan were outward and upward, not downward, thus making such power immensely effective for channel purposes.

From time immemorial, water transportation has been rated as ideal, both in smoothness and in cheapness. That is why even hand-dug canals are to be found the world over. Now that undreamed-of energy has been tapped, one may reasonably believe that atom-dug systems of canals will interlace every continent of the world. Inland pleasure travel by boat may then come into style again.

Land benefits are foreseeable the same as those of water. Prehistoric animals made their trails across mountains, and buffalo and Indians followed them. Next came twin lines of steel and finally ribbons of concrete. All have followed the few mountain passes available, such as through the Rockies. Unlimited explosive power, as revealed by the atom bombs, throws wide open the possibility of cutting mountain passes down further, even blasting small peaks out of the way—in short, of making massive cuts for transcontinental roads.

Many portions of America are spotted with lakes, such as Michigan, Wisconsin and Minnesota; others, such as Kansas, where I came from, hardly know what the word means. Yet standing bodies of fresh water are rated high as both a health and agricultural benefit. I have seen scores of places in my rambles where a little variation of the topography would have made a beautiful lake, with all of the attendant benefits and pleasures. A controlled atomic blast might easily in such a case serve a double purpose—deepen a natural basin and throw up an earthen dam or barrier that would hold the water back and produce a lake.

One may see another variant of the use of atomic energy in earth removal. That is in strip-mining. In many coal and iron ore regions the veins lie only a few feet, maybe 15 or 20, below the surface Stripping off the top dirt is a tedious job. Atomic explosives can be visualized as performing this task in minutes.

Time will be required, of course, to refine atomic power to the point where it can be used for precision jobs. But that will come, sooner perhaps than many of us think. As to what the splitting of the atom will make possible, estimates range all the way from fantastic conceptions by dreamers to remarkable ideas by scientists, whose sober judgment has always made them cautious. A few glimpses will be of interest.

On the seemingly fantastic side, a compendium of scientific opinion, issued more than a decade ago, contained the prediction that enough heat could be generated by smashing the atoms in a pound of water to raise the temperature of 100,000,000 tons of water—as much as flows over Niagara Falls in four hours—from freezing to the boiling point. It asserted that a breath of air contains enough atoms which, if split, would yield the energy to keep a plane flying for a year, or that a heavy train could girdle the globe several times on the atomic energy from a railroad ticket; again, that a puff of cigarette smoke could run a tractor for a year, while from a shoveful of coal could be taken enough power to run all of New York's machinery for five years.

We also look back to 1931 and find the Berlin Institute of Physical Research claiming one gram of water contains $125,000 worth of energy—it would cost that much to produce it by ordinary means. Two years later W. D. Harkness of the University of

Chicago estimated a pound of hydrogen to be equal to 10,000 tons of coal; the atomic energy in a handful of snow would heat a large apartment house for a year; a trip around the world could be made on the energy generated from a teaspoon of water; a gram of matter would send an airplane around the world without stopping to refuel. And now, by way of variety, we have the chief of the United States Rocket Society saying that a trip to the moon by way of atomic power is not only possible, but one may before long go joy-riding among the planets!

On the other hand, within recent days Dr. Samuel K. Allison of the University of Chicago, another great scientist foremost in atom-bomb development said that we may be heating whole cities with atomic energy within a few years. None less than the National Advisory Committee for Aeronautics has just affirmed that "it is not fantastic to visualize a fuel supply the size of a brick with sufficient power to fly around the world many times." The best and most authoritative picture of all is contained in the authorized release on the atom bomb, which spoke of it containing the explosive force of 20,000 tons of TNT.

The main point is, we are at the gateway to a new world, the world of unlimited power. As to the time required to reduce atomic energy to efficient use, one can only guess. Some great minds say a few months to five years, others say a generation, and a few assert it will take a century. A Gallup poll showed people generally believe that "atomic energy will be harnessed to supply power for industrial and other uses within the next ten years." Bearing that out is the statement by Prof. M. E. Oliphant of Birmingham, England, University, one of the scientists responsible for the development of the atom bomb, that inside of the next decade atomic energy will replace all forms of power for large-scale production.

If the atom can be split, it can also be mastered, in the view of most authorities, particularly those associated with the bomb development High regard must be given to the affirmation of Dr. J. R. Oppenheimer, credited by the War Department with being as much responsible for the atom bomb as any other scientist, that world changes by 1965 will be more marked than

those which took place in the two decades following Faraday's revolutionary work with electricity.

There is good reason to expect quick action. We live at a feverish pace as the result of the war, and this pace cannot be expected to slacken much. Reconversion is only the prelude to swift action of many kinds at hand And so great is the realization of the import of the discovery of the means to harness atomic energy that we can expect the greatest peacetime scientific race against time in all history.

We read comparisons of the time it took the auto and the airplane to come into general use The first gasoline auto was invented in Europe in 1882, but widespread use did not begin until about 1910. The plane was two decades reaching general acceptance. When Marconi sent his first wireless waves across the English Channel, he was gravely informed by "experts" that radio waves never would cross the ocean. Yet Marconi did it in just two years!

One would stick his neck out if he attempted to set a minimum time limit on the commercialization of atomic energy; he is wiser if he points to the astounding genius which split the atom, and to other unbelievable attainments of science and industry in recent years, and simply says: "Any time!"

Most authorities to date do not envision early atomic energy plants in autos or airplanes using pinpoint supplies of atoms for power; rather they foresee, at first, atomic energy developed and capitalized in vast generating plants for electricity or direct power, which will be available for every purpose where distributed energy is used. In the case of big ships, of course, atom fission may supply the power direct—in fact, back in 1939 the Navy allotted $2,000,000 for atomic power experimentation for just such a purpose.

Even with such restricted use as that, one can see an incredibly thrilling era ahead. Although each one of us now has something like 113 mechanical slaves working for him, as Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, affirms, that may be multiplied countless times. Homes heated and lighted for a cent or two a day, or by power possibly furnished free as a public utility. Highways across the nation lighted

as bright as day will make night travel a delight. Planes of 2000-miles-an-hour speed are foreseen, with any spot on earth only six or seven hours from one's doorstep. Cities will be scattered because there will be no need for congestion at the source of power. Coal mines will become a curiosity like the dodo. One can have controlled agriculture in his back yard, growing the finest vegetables and fruits as he desires. He need never want for the daintiest and rarest delicacies direct from the garden.

Unlimited power will mean the production of ample food, clothing, housing and other necessities as well as myriad luxuries, for everyone. Poverty and famine, slums and malnutrition will disappear from the face of the earth. Diseases will be attacked with fresh vigor because there is to be an ample margin of time for the cultivation of health and superb care of the body. Abundant time for study and research will make a game of mental development, and intelligence and education will reach a new high. Wars will fade out as an amplitude of production of all things necessary to adequate and enjoyable living anywhere and everywhere will remove the fundamental economic and material rivalries that provoke war. Just as America, with an abundance of resources and with high standards of living, is a peaceful nation, so the spread of wealth over the poorer sections of earth, where wars breed, will destroy the swamps where such evils generate. A new and excellent culture, the like of which the world has never before glimpsed, is likely to come into being.

As to healing, eminent scientists point out that X-rays, radium and atomic energy are links in the same chain of radioactive substances and forces, and therefore an astonishing new era of success in the treatment of disease which X-ray and radium now effectively treat, particularly cancer, may be expected.

The by-products of solving the mystery of the atom will doubtless be as valuable as they will be intriguing. One very intelligent financial editor suggests that unlimited atomic energy may so increase our production that a corresponding enhancing of the national wealth will be so great that it will "outrun our public debt"—in other words, make the public debt relatively such a small item that it can be handled without a convulsion in the process!

No one can chart the future, but evidence is at hand that the greatest magic carpet of all the ages is being unrolled. It remains for man to use it for his own good rather than his ruin. But we need not fear. In the long run, man usually chooses the thing that will keep him going and improve his lot—at least an atomic trifle!

THE ATOM AND EVERYBODY'S BUSINESS [6]

Atomic energy is going to have a profound effect on industry, not only in the individual manufacturing units but on the entire economic structure. There should be an increase in both smaller and larger units: production will be on a higher level of output per worker than ever before, as processes become more automatic. A program of projects on a national scale will be undertaken to utilize both the vast amount of energy that will be available and what would otherwise be an excess of manpower. This will require a coordination of private industry and the national-scale projects. In other words, it will be necessary to have a really planned economy and to have an engineered civilization on scientific principles.

National projects will include rebuilding and redesigning our cities for the new age. The chaotic railroad situation in Chicago, for example, is a civic problem that will tie in with a railroad-unification problem. The situation in New York is slightly better; and in their lesser scales, the same applies to most other cities Street crossings and traffic and parking too are critical problems in cities at the present time. With the coming of the atomic energy automobile, the traffic problem will become one of even greater magnitude for which no solution will be found along the lines now being followed.

Expansion may come to a halt in all of our larger cities, and there may be less need for many of the buildings now crowded into congested areas. The less pleasant industries will probably find it desirable to move to less congested areas, and the elimina-

[6] By John J. O'Neill, Science Editor, *New York Herald Tribune*. From *Almighty Atom, the Real Story of Atomic Energy*. p. 93-4. Ives Washburn, Inc. New York. 1945.

tion of coal as the fuel of industries will make it possible to stop the pollution of the air which is now producing unhygienic conditions in many cities. Pittsburgh, for example, may become a clean city, and Pennsylvania, as a whole, lose the stigma which it now carries, because of the high death rate from pneumonia directly associated with its state of air pollution.

The plan long sponsored by Henry Ford for placing industries in rural areas, from which supplies of manufactured products for other industries can be secured by the work of the farm populations in the slack farm season, and the plan of Farm Chemurgic to produce crops from which can be manufactured raw materials required by industry, in addition to food crops, will make rural areas more prosperous and will halt the drift from the farms to the cities. With these developments there will be a greater uniformity of interests in all parts of the nation: the farm and the urban populations will not be pitted against one another as mutually antagonistic elements of the population, and each will be less vulnerable to manipulation for selfish political purposes.

All of man's freedoms have come into existence only as a result of his conquest of sources of power beyond that in his own muscles. Every civil, political and economic liberty systems from this primary source of all liberties. With atomic energy, man can create a new world in which we are entirely freed from the domination of our environment, in which all of our wants will be generously supplied and every useful luxury made available.

Our civilizations have progressed at a relatively slow rate in the past, but the rate has been continually increasing. In recent centuries, the tempo of civilization can be linked directly to the amount of energy man has had available to him for carrying on his activities. When coal gave us a large increase in available energy we went forward through a rapidly expanding phase of civilization. Now, as atomic energy becomes available, we are going forward at such a pace that progress will seem like a resounding crescendo of advancement with a program of rapidly consummated tremendous projects.

But there is one limitation. Every phase of the manifestation of atomic energy must be directed for human welfare without limitation imposed by those who would seek selfish gains from

it. The hope of a new, peaceful world, peopled by a happy, secure and contented human race, rapidly evolving to a higher destiny, can be sold for a 20 per cent reduction in our electric-light bills—if we permit this great blessing to be monopolized by interests lacking in the new social viewpoint.

Because this is so, atomic energy will become the major political, economic, social and international issue, starting now. Its control must be in the hands of the people. It is too great a boon to be permitted to become the plaything of selfish groups that would obtain profits from it at the price of a new civilization for the entire race of men. The present administration is well aware of the latter danger and has shown indications that it intends to hold control of atomic energy—at least for the present. But no one knows how long "temporary" means. There is a danger in government monopoly as well as in industrial monopoly.

Probably the greatest responsibility that rests upon the people of the United States today is to determine just how atomic energy shall be administered for the creation of universal human welfare. This calls for a grandiose type of planning, compared to what we have been doing in the past; it calls for planning on a gigantic scale and a gargantuan motif for our works. The critical element in the atomic-energy age will be man himself. Will he measure up to the possibilities of the tremendous source of power now placed in his hands?

EXCERPTS

As a result of the inventive, scientific, industrial and engineering advances incident to work on the atomic bomb project, it is estimated that more than 5,000 new and improved products and procedures are now available to American industry awaiting only government release for volume production.—*M. W. Kellogg Company. Memorandum. S.* 17, '45.

French scientists are considering experiments with atomic energy in the Sahara Desert with the purpose of raising to the surface the natural water resources which are found many hundreds of feet below ground, thus converting the waste land into an

oasis As soon as we have the suitable material we can make available huge sources of light and heat by means of which we can settle such deserted regions as the Arctic and Antarctic. We could control the spectral composition of this light through an appropriate choice of luminous compounds. This artificial sun giving off light and heat can be directed towards a storage plant in which fruits may be ripened and their vitamin content raised.—*Boris Pregel, Economist and Engineer; President of Canadian Radium and Uranium Corporation; in address at New School for Social Research, May* 23, 1946. *Commercial and Financial Chronicle. My.* 30, '46. *p* 2979.

Were I economic director of the United States, I would . . . immediately reconvene the scientists who worked on the atomic bomb and get them busy applying this new energy to everyday uses We might still be in the depression of the 1870's, if steam energy had not pulled us out. We might still be in the depression of the 1890's, if electrical energy hadn't then been harnessed. We would now be suffering from World War I, if the gasoline engine had not saved the day. Atomic energy may well serve a similar purpose to prevent a collapse around 1950.

I admit that the best authorities tell me that such an atomic development within the next five years, is an impossibility. The stakes—namely the avoidance of national bankruptcy—are so high, however, that we should at once make a tremendous effort to show these "authorities" that they are wrong We *must* immediately harness this new energy to develop new industries and new jobs.

Atomic energy for industrial and utility uses means vastly more than the substitution of atomic energy for coal and oil. Atomic energy produces an entirely new heat which is actually a new power. Atomic energy may be as much of an advance over steam power as steam power was an advance over hand power. Atomic energy will result in entirely new industries and vastly different machines than now exist, all of which will provide millions of new jobs *if we get it harnessed in time.* In short, to me the question is either of harnessing atomic energy before 1950

or perhaps facing national bankruptcy soon thereafter.—*Roger Babson, "Business and Atomic Energy". Commercial and Financial Chronicle. N. 29, '45. p. 2583.*

To the familiar fields of civil, mechanical, electrical, electronic, and chemical engineering, a new one has been added by the physicists—nuclear engineering. Before the war, nuclear physics had provided practical engineers with a host of new things having peaceful uses—neutrons for cancer therapy, artificial radioactive materials for treatment of leukemia and cancer and for use in fundamental chemical studies, both in biology and in chemical industry. So important was this field of work just before the war that several large companies were considering the manufacture and sale of radioactive materials. The war interrupted this activity and placed over all nuclear research a tight secrecy restriction, but it enormously accelerated the research that resulted so dramatically in the atomic bomb.

With the war ended, we can devote our energies to active cultivation of the applications of nuclear engineering to peaceful purposes—to better ways of producing neutrons and high-energy electrons for therapy and artificial radioactive materials for all kinds of uses. Moreover, we are standing on the threshold of the era in which atomic power will be developed.

All sorts of prophecies are being made about atomic power. Some say it will come only in the very distant future and may not then be practical; others are rashly predicting automotive power from U-235 in a very few years. The wide variance in predictions comes about largely, of course, from the fact that most of the prophets have little more than a crystal ball to guide them. Whatever the prophets say, atomic energy will surely offer some of the most important engineering possibilities of the next generation —*United States. Senate. Special Committee on Atomic Energy. Essential information on atomic energy. Committee monograph no. 1. 79th Congress, 2d session. '46. p. 5.*

The release of atomic energy would not have been possible without an infinite number of prior technological changes. The very organization of the atomic experiment is relevant to the

problem of the influence of technological changes on urbanization. Federal hydroelectric projects enabled the government to localize cities of as many as 75,000 workers in previously isolated areas in Tennessee and Washington. At these sites were installed productive facilities utilizing the most advanced industrial processes, materials, and products.

Recent changes along all these lines have been extraordinary. The need for rapid production of war materials necessitated, and government financing of research and application made possible, numerous innovations which otherwise would have required a much longer period for development Increased experimentation led to great progress in manufacturing techniques. Critical shortages of conventional materials and great advances in techniques for producing or fabricating materials led to the development of new or improved materials. Designs of planes, ships, trucks, and other mechanized equipment have steadily improved; jet propulsion and the gas turbine have been effectively developed; instruments have been made vastly more precise; and there has been tremendous progress in the development of radar and other electronic devices.

Each and all of these advances and many others will influence the design of the future city as they have already affected the developments of cities during the war. They will influence the distribution and growth of populations, the intercommunication of communities, and the ideas, attitudes, and standards of living of countless millions. As a result of the interwebbing of the peoples, trade, and industry of the world, the planning of cities, to be fully effective will have to be in the context not merely of state, regional, and national planning, but of international planning as well. At the same time, world planning, to be rational and fruitful, will be obliged to take into consideration not merely the plans of nations, regions, states, and cities, but the interests of neighborhoods, of families, and of the individual personality. Recent technological changes make it possible for centralization and decentralization to be not antithetical but complementary processes.—*Bernhard J. Stern, Lecturer in Sociology, Columbia University; Chairman, Board of Editors, Science and Society. Annals of the American Academy. N. '45. p. 47-8.*

BIBLIOGRAPHY

An asterisk (*) preceding a reference indicates that the article or a part of it has been reprinted in this book

Bibliographies

Carnegie Endowment for International Peace. Library. Security in the atomic age· international control of the bomb, an annotated bibliography with supplementary list of documentary materials on national problems of control Helen L Scanlon, comp (Select bibliographies no 15) 20p mim. The Endowment. 700 Jackson Pl. Washington 6, D C Ap. 12, '46.

Northwestern University. Technological Institute. Library. Bibliography on the atomic bomb. 13p processed. The Library Evanston, Ill. N. '45.

United States. Library of Congress. General Reference and Bibliography Division. Social impact of science: a select bibliography, with a section on atomic power. [M. C Leikind, comp] Subcommittee on War Mobilization of the Committee on Military Affairs, United States Senate, pursuant to S Res. 107 (78th Congress) and S Res. 146 (79th Congress) authorizing a study of war mobilization problems. August 1945. (79th Congress, 1st session Senate Subcommittee monograph no. 3) 51p Government Printing Office. Washington, D C '45.

United States. Senate Special Committee on Atomic Energy Bibliography· books and articles on scientific and political aspects of atomic energy *In* Essential information on atomic energy. (Committee monograph no. 1) 79th Congress, 2d session. p 59-94 Government Printing Office Washington, D.C '46.

Publishers' Weekly 148 583-5 Ag. 18, '45. Publishers bring out new books on atoms.

General References

Books and Pamphlets

Alois, pseud Peace and the common man, world peace through the achievement of mind-peace. 88p. William-Frederick Press New York. '46.

Andrews, Donald. Inside the atom. (Beyond victory program no. 123) 5p. mim World Wide Broadcasting Foundation 598 Madison Ave. New York 22. '45.

Ausubel, Nathan, ed. Voices of history, 1945-46; speeches and papers of Roosevelt, Truman, Churchill, Attlee, Stalin, De Gaulle, Chiang and other leaders delivered during 1945. 810p. Gramercy Publishing Co. New York. '46

Baker, John R. Science and the planned state. 120p. Macmillan Co. New York '45.

Bernal, John D. Social function of science. 482p. Macmillan Co. New York. '39.

Bethe, Hans A. and others. Atomic age. 14p. United States Rubber Co 1230 Avenue of the Americas. New York 20 '45

Black, Algernon D. War or peace: science forces the issue 9p. mim. New York Society for Ethical Culture. 2 W. 64th St. New York. N 11, '45

Bliven, Bruce and Mezerik, A. G. Foreword; the bomb and the future *In their* What the informed citizen needs to know. p. xi-xiii. Duell, Sloan and Pearce New York. '45

Born, Max Atomic physics 352p Blackie & Son London. '35.

Bowman, Melvin G Nuclear energy and the atomic bomb 4p. Association of Oak Ridge Scientists Box 1251. Oak Ridge, Tenn
Reprint from Chemical Bulletin.

Brown, Harrison Must destruction be our destiny? 158p Simon and Schuster. New York. '46

Burton, Milton Atomic bomb and its implications. 17p. mim. Association of Oak Ridge Scientists. Box 1251. Oak Ridge, Tenn. n.d.

Bush, Vannevar. Science the endless frontier; report to the President on a program for postwar scientific research. 184p. Government Printing Office. Washington, D C. '45

Cable, Emmett J.; Getchell, R. W. and Kadesch, H. K. Science in a changing world. Ch. 7. Building stones of matter. Prentice-Hall. New York. '46.

Chubb, L. W. World within the atom. 31p (Little science series booklet) School Service Westinghouse Electric Corporation 306 4th Ave. P.O. Box 1017. Pittsburgh 30, Pa. '46.

Compton, Arthur A Contribution made by Washington University in the study and development of atomic energy. 20p. Washington University, St. Louis, Mo. '45.

*Cousins, Norman. Modern man is obsolete. 59p. Viking Press New York. '45.

Crowther, James G. Social relations of science. 665p Macmillan Co. New York '41.

Davis, Watson. Release of atomic energy. ("Confidential—from Washington." no. 31.) [4]p. George Washington University. Washington, D C. Ja. '46.

Dietz, David. Atomic energy in the coming era. 184p. Dodd, Mead & Co. New York. '45.

Einstein, Albert and Infeld, Leopold. Evolution of physics. 319p. Simon & Schuster. New York. '38.

Federal Council of the Churches of Christ in America. Atomic warfare and the Christian faith; report of the Commission on the Relation of the Church to the War in the Light of the Christian Faith 24p The Council. 297 4th Ave New York 10. '46.
Printed as a supplement to Social Action, April 1946.

French, Sidney J. and Dodge, Homer L Challenges of the atomic age. two addresses delivered at Colgate University [23p] Colgate University Hamilton, N Y. '45

Gamow, George. Atomic energy in cosmic and human life 161p. Macmillan Co. New York '46

Gamow, George. Birth and death of the sun. 238p. Viking Press. New York. '40

Gamow, George. Mr Tompkins explores the atom 97p Macmillan Co. New York. '44.

Gordon, David. Atom of the solar system. 31p William-Frederick Press. New York. '46.

Great Britain Treasury. Statements relating to the atomic bomb. 23p. His Majesty's Stationery Office London. '45
Same. Reviews of Modern Physics 17 472-90. O '45.

Hawley, Gessner G and Leifson, Sigmund W. Atomic energy in war and peace. 211p Reinhold Publishing Corp. New York '45.

Holmes, John H. Is the end at hand? what we may expect of the atomic bomb. 21p Community Church. 40 E. 35th St New York 16. '46.

Infeld, Leopold. Atomic energy and world government. (Behind the headlines. Vol. 6, no 4) 20p Canadian Institute of International Affairs 230 Bloor St Toronto 5 '46

Jaffe, Bernard. Ernest Orlando Lawrence, the turn of the tide in world science. *In his* Men of science in America p 505-41. Simon and Schuster New York. '44.

Jordan, Virgil Frame of America's future. *In* American Petroleum Institute. Proceedings, November 12-15, 1945 p 25-31 The Institute 50 W. 50th St New York 20. '45

Jordan, Virgil Manifesto for the atomic age 70p Rutgers University Press. New Brunswick, N J '46.

Kaempffert, Waldemar Should the government support science? (Pam no. 119) 32p Public Affairs Committee 30 Rockefeller Plaza New York 20 '46

Kaempffert, Waldemar and others America's atomic bomb· what shall we do with it? radio discussion 36p. World Peaceways 103 Park Ave. New York 17. '45.

Kaempffert, Waldemar and others. Social implications of the atomic age; report of a symposium. 16p. Jewish Forum. 305 Broadway. New York 7. '46
Reprint from Jewish Forum, December 1945 and January 1946

Kingdon, Frank. Radio addresses over WMCA, October 3, 1945-date. mim. WMCA, 1657 Broadway. New York 19.

Knox, Ronald A God and the atom. 166p. Sheed & Ward. New York. '45.

Levy, Hyman. Peace and the atom. 32p. Muse Arts, Ltd. 48 S. Molton St. London W1; Universal Distributors Co. 38 Union Sq. New York S. '45.

Marshak, Robert E.; Nelson, E C. and Schiff, L. I. Our atomic world. 72p. University of New Mexico Press. Albuquerque. '46.

Masters, Dexter and Way, Katharine, eds. One world or none. 79p. McGraw-Hill Book Co. New York '46.

Contents Introduction. A H. Compton, Science and civilization Niels Bohr; If the bomb gets out of hand Philip Morrison; It's an old story with the stars Harlow Shapley, Roots of the atomic age. E P Wigner; New power. Gale Young; New weapon. the turn of the screw. J. R. Oppenheimer; Air force in the atomic age. H. H Arnold; There is no defense. L. N Ridenour; New technique of private war. E. U Condon, How close is the danger? Frederick Seitz and Hans Bethe; Atomic arms race and its alternatives. Irving Langmuir; How does it all add up? Harold Urey, Can we avert an arms race by an inspection system? Leo Szilard; International control of atomic energy Walter Lippmann; Way out. Albert Einstein, Survival is at stake Federation of American (Atomic) Scientists

Mumford, Lewis. Program for survival. *In his* Values for survival. p. 78-130. Harcourt, Brace & Co. New York '46.

National Institute of Social Relations. Atomic energy—disaster or blessing? (Talk it over. Series G-101) 12p. The Institute. 1029 17th St. Washington 6, D.C. '46.

Discussion guide.

National Policy Committee. Memorandum of the Washington dinner on science and public policy (Memoranda no. 41) 23p. The Committee. 1202 National Press Bldg Washington 4, D.C. '45.

National Policy Committee. Memorandum of the Washington dinner on science under government auspices. (Memoranda no. 42) 23p The Committee 1202 National Press Bldg. Washington 4, D.C. '45.

*O'Neill, John J. Almighty atom; the real story of atomic energy. 94p. Ives Washburn. New York '45.

Pollard, Ernest C. and Davidson, W. L Applied nuclear physics 249p. John Wiley & Sons. New York. '42.

Potter, Robert D Atomic revolution 165p. Robert M. McBride & Co. New York. '46

Rabi, Isidor I Atomic nucleus, radio broadcast, New York Philharmonic Symphony program 4p United States Rubber Co. 1230 Avenue of the Americas. New York 20. '46.

Ratcliff, John D. ed Science year book of 1946. p. 1-29. Doubleday & Co. Garden City, N.Y. '46.

Robertson, John K. Atomic artillery and the atomic bomb. rev. & enl. 168p. D. Van Nostrand Co. New York. '45.

Rusk, Rogers D. Forward with science. 307p. Alfred A. Knopf. New York. '43

Rutherford, Ernest R. Newer alchemy. 67p. Macmillan Co. New York. '37.

Rutherford, Ernest R. Transmutation of matter. *In* Smithsonian Institution. Annual report, 1938 p. 201-8. The Institution Washington, D.C. '39.

Schacht, Henry. Touring the atomic world. *In* Shapley, Jarlow and others, eds Treasury of science. p 200-9. Harper & Bros. New York. '43.

Semat, Henry. Introduction to atomic physics. rev. & enl. 412p Rinehart & Co. New York. '46

Smith, Wilbur M Atomic bomb and the word of God 30p Moody Press. Chicago. '45.

Smyth, Henry DeW Atomic energy for military purposes; the official report on the development of the atomic bomb under the auspices of the United States government, 1940-1945. 308p. Princeton University Press Princeton, N J '46.

Same. Reviews of Modern Physics 17 351-471. O '45, *Abstract* Review of Scientific Instruments 16 260-3 S '45; *Condensed* Journal of Applied Physics 16 493-500 S '45.

Social Science Foundation of the University of Denver and the Rocky Mountain Radio Council Journeys behind the news; radio transcripts mim. The Foundation. Denver, Colo.

No. 14. Kinney, D. W Challenges to the U N O.; Atomic Control Commission. 9p D 8, '45

No 19 Watson, James Atomic energy, scientific facts and peacetime possibilities 8p Ja 12, '46

No 20. Watson, James Atomic energy, peacetime possibilities 9p Ja. 19, '46.

No. 21 Watson, James. Atomic energy; legislation for the atomic era. 8p Ja. 26, '46.

No 22. Watson, James Atomic energy, a look at the future. 8p. F. 2, '46.

No 23. Watson, James Atomic energy; the United Nations Organization and atomic energy control 8p F 9, '46

No 31. Fuller, C Dale Battle for atomic energy legislation—round 1. p 213-20. Ap. 6, '46. Bibliography, p. 218-20

No. 32 Fuller, C Dale. America's choice atomic war or atomic peace. p. 221-7. Ap 13, '46. Bibliography, p 226-7.

Solomon, Arthur K. Atoms and cyclotrons. *In* Ward, Harold, ed. New worlds in science. p. 423-41 Robert M. McBride & Co. New York. '41

Solomon, Arthur K Why smash atoms? rev. ed 204p. Harvard University Press. Cambridge, Mass. '46.

Stokley, James. Atomic energy. *In his* Electrons in action. p 275-92. McGraw-Hill Book Co. New York. '46.

Wendt, Gerald and Geddes, Donald P. eds Atomic age opens. (Forum Books) 251p. World Publishing Co. New York. '45.

Pocket Book edition. (No 340) 253p. Pocket Books, Inc. 1230 6th Ave New York 20 '45.

World Peaceways. World observer. [4p. mim. papers]. World Peaceways 103 Park Ave. New York 17.

Titles: Should the atomic bomb be outlawed? S. 9, '45; Can we counteract the atomic bomb? O. 21, '45, Remember Pearl Harbor—or Hiroshima's atomic bomb! D 9, '45; Should the army or civilians control the atomic secret? Mr. 3, '46; Can we base our atomic policy on fear? Mr. 31, '46, Psychology's advice on the atomic bomb. Je. 16, '46.

Yates, Raymond F. Atom smashers; a story of discovery 182p. Didier. New York. '45.

Ziff, William B. Two worlds; a realistic approach to the problem of keeping the peace 335p. Harper & Bros. New York. '46.

PERIODICALS

Aero Digest. 51·33-7+. D 1, '45. Nature and portent of atomic power. W. F G. Swann.

Air Transport. 3.91. S. '45. Uranium sources to provide plenty of U-235.

Air Transport 3:92+. S. '45 Fifty-years research preceded perfection of the atomic bomb.

American Affairs. 7.219-23. O. '45. Before and after the event of July 1945.

American City. 60·98. S. '45 Can human freedom survive atomic energy? our public schools have a grave responsibility. M L. Walker.

American Journal of International Law. 39:736-44. O. '45. Atomic bombs in international society; will it brutalize the men who wield it? E. D Thomas.

American Journal of International Law. 39:784-8. O. '45. Laws of war and the atomic bomb. E. C. Stowell.

American Journal of Physics. 14:30-5. Ja '46. Brief account of the physics of the atomic bomb. R. J. Stephenson.

American Journal of Sociology. 51:267-75. Ja. '46. Sociology and the atom. W. F. Ogburn.

American Journal of Sociology. 51.558-9. My. '46. Sociology and the atom; reply. D R. Taft.

American Mercury. 57.441-7. O. '43 Case for planned research. Waldemar Kaempffert.

American Mercury. 62:431-7. Ap. '46. How the next war will be fought. W. B. Huie.

*American Philosophical Society. Proceedings 90, no. 1:1-79. Ja. '46. Symposium on atomic energy and its implications.

Contents· Fifty years of atomic physics. H. D. Smyth; Atomic weapons J. R. Oppenheimer, Health protection activities of the plutonium project R. S. Stone, Development of the first chain reacting pile. Enrico Fermi; Resonance reactions E P Wigner, Methods and objectives in the separation of isotopes. H. C. Urey, Problems and prospects in elementary particle research. J. A. Wheeler, *Social adjustments to atomic energy J. H. Willits, Implications of the atomic bomb for international relations. Jacob Viner; Control of atomic energy under the charter. J. T Shotwell; World control of atomic energy. Irving Langmuir; *Atomic energy as a human asset. A. H Compton.

American Political Science Review. 40:445-57. Je. '46. Physics and politics. C. E. Merriam.

American Teacher. 30:15-17. Ja. '46. Science and the atomic bomb. B. T. Feld.

Antioch Review. 5:459-62. D. '45. Editorial.

*Antioch Review. 5.463-79. D. '45. With all our learning. M. C. Otto.

Antioch Review. 5:480-92. D. '45. Military consequences of atomic energy. Joseph Rosenfarb.

Antioch Review 5·493-500 D. '45. Democracy and science fused by the atomic bomb. J. F. Sembower.

Antioch Review. 5:504-10 D. '45. Atomic energy in practice. Gwilym Owen.

Association of American Colleges Bulletin. 31:362-5 O. '45 Can the colleges cope with the challenge?

Association of the Bar of the City of New York. Record. 1·13-31. F. '46. Science. a problem in legislation. O. M. Ruebhausen.

Atlantic Monthly. 176.107-14. O. '45. Physicist returns from the war. I. I. Rabi

Atom. 1·1-32. Fall '45. (ed. by Ronald Kurtz and J. F. Ferguson. Atomic-Age Publishing Co. 1950 Curtis St Denver 2, Colo)

Contents. What atomic power may do for you. Duncan Clark, Sun, majestic atomic furnace Roscoe Fleming, What is an atom? E A Engle, Handy list of terms and names; Story of radioactivity Eric Gilmore, Splitting the atom. C M. Knudson; Rays from outer space Lee Fredericks, Laboratory in the clouds. W. H Hyslop, Two bombs that shook the world D. C. Campbell, Descriptions of the various atoms, Father of the atomic theory. Ronald Kurtz, Atomic theory among the ancient Greeks Mehdi Nakosteen

Atom 2, no. 1 24-6 Spring '46. Atomic journal, convenient day-by-day summary of important news on atomic energy

Atomic Information. National Committee on Atomic Information. 1621 K St. Washington 6, D.C

Vol. 1, no 1 Mr 4, '46—date. Published fortnightly

Aviation 44:106-7+. S. '45. Atomic frame of reference—or else. Herb Powell

British Speeches of the Day 3:643-7. D. '45. Speech in House of Commons, November 22, 1945; extracts. Clement Attlee

Bulletin of the Atomic Scientists. (Atomic Scientists of Chicago. 1126 E 59th St Chicago 37)

Vol. 1, no 1. D 10, '45—date

*Bulletin of the Atomic Scientists. 1 6. F. 1, '46. Distribution of uranium in nature

Bulletin of the Atomic Scientists. 1:1-16. Mr. 15, '46

Partial contents. Military or civilian control of atomic energy?, Moral responsibilities of scientists A V Hill, How Germany lost the race. S A. Goudsmit; Appeal to reason. E. U. Condon; Senate hearings on atomic energy: atomic bomb patents, Public utilities and atomic power.

Bulletin of the Atomic Scientists 1, no. 8:1-20. Ap. 1, '46.

Partial contents. Plans for international control take shape; State Dept report on the control of atomic energy, State Dept. report, a ray of hope Edward Teller, Draft for a convention on atomic energy. Quincy Wright; Atomic energy and the UNO Atomic Energy Commission. P. M. S. Blackett, Scientist's visit to England and France. J A. Simpson, Jr.

Bulletin of the Atomic Scientists. 1, no. 9:1-20. Ap. 15, '46.

Partial contents. Revised McMahon bill, Some political implications of the State Dept. report. E A. Shils, Denaturing fissionable materials, Dispersal of cities and industries. J. Marshak, E. Teller and L. R. Klein, Uses of radioactive pile products.

Bulletin of the Atomic Scientists 1:1-16. My. 1, '46.
Partial contents Before Hiroshima; Report to the Secretary of War; France and atomic energy. Frederic Joliot; Atomic bomb damage—Japan and USA R. E Marshak, E C Nelson and L I Schiff; Physics and politics. C. F Merriam, Atomic energy in the House of Commons. E A. Shils.

Bulletin of the Atomic Scientists. 1:1-16. My. 15, '46.
Partial contents: Dangerous lull; Hiroshima—August 6, 1945. J A. Siemes; What about the Bikini tests? L. A. DuBridge, Science and international co-operation. E U. Condon; Science and national policy L. A. DuBridge; Government patent rights. G K. Lister.

*Bulletin of the Atomic Scientists. 1·1-16. Je. 1, '46.
Partial contents· *International control of atomic energy. J. R. Oppenheimer, Suggested amendment to the Acheson report. E Teller; Memo to the UN Atomic Energy Commission Atomic Scientists Committee of Great Britain; Application of isotopes to biology. M. D Kamen; Acheson report and Chicago draft convention E. Rabinowitch, ADA and the veto power. D. R. Inglis.

Bulletin of the Atomic Scientists. 2·1-24. Jl. 1, '46
Contents: American and Russian proposals; Report on U N. Atomic Energy Commission, American proposal for international control B. M Baruch; Russian proposal for international control. Andrei Gromyko, Beginning for sanity· a review of the Acheson-Lilienthal report Norman Cousins and T. K Finletter; Carnegie draft convention; Availability of radioactive isotopes, announced by the Manhattan Project, Status of domestic legislation.

Business Week. p. 15-18. Ag. 11, '45 Enter. the atomic age.

Business Week. p. 57-64. S. 1, '45. Atom, new source of energy. J H. McGraw, Jr.
Same. American Machinist 89 112a-112h S. 13, '45; Aviation. 44·102a-102h S. '45, Electrical World. 124:102a-102h. S 1, '45; Electronics. 18: 88a-88h. S. '45, Bus Transportation 24·39-40, 40a-40f. S. '45; Engineering News-Record. 135 272a-272h. Ag. 30, '45; Food Industries. 17:8p insert following p. 66 S '45, Power. 89·604b-604h. S '45, Air Transport 3·59-66. S. '45, Product Engineering. 16 592a-592h. S '45; Engineering and Mining Journal 146 66a-66h S '45

Business Week. p. 19-20. Ap. 20, '46. Atomic power search widens; new program of research.

Business Week p. 66-72 Jl. 6, '46. This fateful atom can serve man.

Canadian Chemistry and Process Industries 29:554-6+. Ag. '45. Canada's contribution to atomic energy

Canadian Mining Journal 66 614-16. S '45. Atomic bomb; Canadian scientists and uranium played important role.

Catholic World 161 449-52. S. '45. Atom bomb J. M. Gillis

Catholic World 163.144-51. My '46 God, man and the atom bomb. F X Murphy.

Chemical Age (London). 53·194, 200 S. 1, '45. Realisation of the atomic bomb; contribution by British industry.

Chemical Age (London). 53.355-9. O. 20, '45. American work on the atomic bomb

Chemical and Engineering News. 23.2317-21 D. 25, '45. Scientist and the war. J H. Hildebrand.

Chemical and Engineering News. 24.1192-8 My. 10, '46. Impact of nuclear chemistry G T. Seaborg

Chemical and Metallurgical Engineering. 52:102-6. S. '45. Conquest of uranium and the atomic bomb.

Chemical and Metallurgical Engineering 52:106-8. S. '45 How Hanford solved the problem of synthesizing an element. J. R. Callaham.
Chemical and Metallurgical Engineering. 52:98-101. D. '45. Oak Ridge gives industry a unit operation gas diffusion J. F. Hogerton
Chemical and Metallurgical Engineering. 52:236+. D. '45. Atom bomb and German science; abstract. A A. Bates
Chemical and Metallurgical Engineering. 53·111-12. Ja.; 107-11. F '46. Award for chemical engineering achievement to go to atomic bomb project. S. D Kilpatrick.
Chemical and Metallurgical Engineering 53:112-22. F. '46. Role of the process engineer in the atomic bomb project P. C. Keith.
Chemical and Metallurgical Engineering 53:100-5 Mr. '46. Chemical engineering profession honors A-bomb project; award to Manhattan Engineer District; with speeches by A H. White and L. R. Groves.
Chemical Industries. 57·450-2+. S. '45. Technology of the atomic bomb; editorial staff report.
Chemistry. 19·26-8. O. '45. Dates in atomic history
Chemistry 19:1-9. D. '45. Four newest elements. G. T. Seaborg
Chemistry 19:17-30, 12-22. D. '45; Ja '46. Fifty years of radiology. R. S Stone
Chemistry and Industry p. 52 F 2, '46 Nucleus of the atom P. L Robinson.
Christian Century 62:674-6 Ag. 29, '45. America's atomic atrocity.
Christian Century 63·330-3 Mr 13, '46. Atomic bomb and the Christian faith. C. C. Morrison
Christian Century. 63:556-8. My. 1, '46. Reconciliation or atomic destruction. E F Tittle.
Christian Science Monitor Magazine Section. p. 5. O. 13, '45. Atom bomb· what next? Don Jackson
Christian Science Monitor Magazine Section. p. 2. O. 27, '45 What holds the atom together? R. K. Shellaby
Christian Science Monitor Magazine Section p. 6-7+. Ja. 12, '46 Atomic power in war and peace. A H. Compton.
Collier's. 116 11-13+. O. 13, '45. Man who made Manhattan; [General Groves]. Robert De Vore.
Collier's. 116 11-12+. D 8, '45. Air power in the atomic age. C. A. Spaatz.
Collier's. 117:18-19+. Ja. 5, '46. I'm a frightened man; ed. by M. Amrine. H. C. Urey.
Separate, 7p. National Committee on Atomic Information. 1749 L St. N.W. Washington 6, D C.
Collier's. 117.65. Ja. 5, '46. Week's work; Dr. Harold Clayton Urey.
Collier's. 117·11-12+. Ja. 12, '46. Blunder; a story of the end of the world. Philip Wylie.
Collier's. 117:19+. Mr. 2, '46. What the atomic bomb really did. Robert De Vore.

Collier's. 117·12-13+. My. 11, '46. Atomic age navy. C W. Nimitz.
Commentary. 1.17-26. D. '45. Nobel's prizes and the atom bomb; the story of history's strangest pacifist experiment. Hertha Pauli.
Commerce Magazine 42:25-6+. O. '45. Story behind the atomic bomb. Reuben Gustavson.
Commercial and Financial Chronicle. 162·1695+. O. 11, '45. Urges more science for security. David Sarnoff.
Commercial and Financial Chronicle. 162:2371. N. 15, '45. De Seversky discounts effectiveness of atom bomb on U.S cities of steel
Commercial and Financial Chronicle. 163:533+. Ja 31, '46. Scientific research and economic development. G R. Harrison.
Common Sense. 14:3-5. O. '45. How to avoid the atomic war. Bertrand Russell.
Common Sense 14:15-17. O. '45. Full employment and the atomic bomb A. P. Lerner
Common Sense. 14:28-9. O. '45. Atomic age balance sheet. Stuart Chase.
Commonweal. 44·206-11. Je 14, '46. Minutes on our destiny; world's problem. Ely Culbertson.
Congressional Record. 92·(daily)A385-7. Ja. 30, '46. Atomic bombs in international society. E. D. Thomas
Congressional Record. 92:A875-6. F. 18, '46 Atomic energy and world cooperation Paul Bolton
Congressional Record 92.(daily)A1850-2. Mr 28, '46 Bomb that fell on America, poem. Hermann Hagedorn
Congressional Record. 92:(daily)A2190-1. Ap. 11, '46. Atomic bomb; questions and answers given on radio program
Congressional Record. 92.(daily)A3394. Je. 6, '46. Atomic research in Russia. Eddie Gilmore
Congressional Record. 92 (daily)A4508. Jl 19, '46 Huge atomic research center is planned for New York area.
Reprint from New York Herald Tribune Jl 19, '46
Coronet. 19 4-8. Ja. '46. Last warning to the world Tris Coffin.
Debaters' Digest. 20.25. Mr. '46. Has the atomic bomb ended the need for compulsory training? no!
Domestic Commerce 34 19-21. F. '46. What's the future of uranium and kin? Walter Janssen.
Economist (London). 149.665-6. N. 10, '45. Atom.
Education. 66 499-502. Ap. '46. Schools and the atom J H. Starie.
Educational Forum. 10:331-9. Mr. '46 Prelude to Hiroshima. R. C. R MacFarlane.
Educational Leadership. 3:232 F. '46. Atomic energy must work for humanity E. O Melby.
Electrical Engineering. 64 315-18 S. '45. Beginnings of nuclear physics K. K. Darrow.
Electrical Engineering. 65:108-16 Mr. '46. Progress in nuclear research; review of highlights in development of the atomic bomb.

Electrical West 95.105-7 S '45. Nylon hose or atomic bombs; Hanford project. W. C. Heston.

Electrician (London). 135·134-5, 196. Ag 10, 24, '45. Atomic energy; early work which led to development of new bomb.

Electrician (London). 135:196. Ag. 24, '45. Atomic energy; further details of developments in British laboratories.

Electrician (London). 136:26. Ja. 4, '46. Nature and uses of atomic energy, abstract. L. E. C Hughes.

Electronics 18:109-13. O. '45. Technical basis of atomic explosives; production and use of uranium 235 and plutonium

Engineer (London). 180.417-19. N. 23, '45. Scientist in wartime. Edward Appleton.

Engineering. 161:75-6, 100. Ja. 25, F. 1, '46 Production of atomic energy. J T. Kendall.

Engineering News-Record 135 834-5. D. 20, '45. Atomic bomb damage at Nagasaki.

Explosives Engineer. 23 189-91+ S. '45. Atomic power; semi-technical article on this epoch-making development. R W. Cairns and W. P. Connor.

Facts on File; Weekly World News Digest. 516 5th Ave. New York 18.
See indexes.

Fellowship. 11.208-9. D. '45. Conscience against the atomic bomb. A J. Muste.

Flying 38.38-9+. F '46. Push-button warfare; atomic missiles, guided by radio and television, will soon outmode our present concept of air power. William Roger.

Flying. 38·21+ Mr. '46. Atom and aviation. W. F. Ogburn.

Food Industries. 18.69-76 Ag. '46 Man vs atom—year 1.

Fortune 32:sup 1-14 S '45. Science, the endless frontier; report to the President on a program for scientific research; abridged. Vannevar Bush.
Summaries Science. 102:74-81. Jl 27, '45, Science News Letter 48 51-3. Jl. 28, '45; Scientific Monthly. 61.482. D '45

Fortune. 32.305-6+. D. '45 Fortune survey; use of atomic bomb.

Fortune. 33:116-17+. Ja. '46. Pilot lights of the apocalypse; playlet in one act; [plea for avoidance of atomic-armaments race]. L. N Ridenour.
Same. Scholastic. 48.17-19+ Ap 29, '46.

Fortune. 33:187-8. Ja '46. State versus planning. John Chamberlain.

*Fortune. 33:136-44+ Mr. '46 Nature of the atom Lise Meitner.

Fortune 33:114-22+. My '46. Physics of the bomb. A. K. Solomon.

Fortune 33 116-21+. Je. '46. Great science debate; atom touched off great debate on national science policy.

Forum 104:40-1. S. '45. Atomic bomb. H. W. Baldwin.

Forum. 104·231-3. N. '45. Morality of the atomic age. E. C. Lindeman.

Franklin Institute. Journal. 227:443-59. Ap. '39. Our knowledge of atomic nuclei. G. P. Harnwell.
Same. Smithsonian Institution. Annual report, 1939:189-202. '40.

Free World. 10·28-9. S. '45. Now or never. Orson Welles.
Free World. 10:34-6. S. '45. Japan and the end of the world. Herbert Corey.
Free World. 10:37-9 S. '45. X equals the future Laura Vitray
Free World. 10:71-4. S. '45. Man and the atom Norman Angell.
Free World. 10:76-8. O. '45. Atomic bomb and human rights. A. P. McCann.
Free World. 10·21-3. D. '45. What can the individual do in the atomic age?
Free World 10:74-6. D. '45 Human nature and the atomic age. Norman Angell.
Free World. 11:14-15. Je. '46. Autobiographical notes of an atomic bomb. Milton Rugoff.
Gas Journal (London). 246:293, 337, 365. Ag. 29-S 12, '45. Atomic energy
General Electric Review. 49:8-9. Ja. '46. Atomic power. Guy Bartlett.
Harper's Magazine. 181:1-10. Je. '40. Enter atomic power. J. J. O'Neill.
Separate. 12p. Harper & Bros. New York. '45.
Harper's Magazine. 191:312-17 O. '45. Status quo or pioneer? fate of American science. Harlow Shapley.
High Points. 27:5-8. S '45. Atomic bomb shakes the classroom. H I. Christ
Higher Education. 2:3-6 My. 1, '46. Further development of science legislation. L. E. Blauch.
Illustrated London News 207.169, 176-87, 194. Ag. 18, '45. See various articles.
Illustrated London News 207.198. Ag 25, '45 Destruction of what remained of the potential peace of mankind. Arthur Bryant.
Illustrated London News. 207 214. Ag. 25, '45. Future of world security. Cyril Falls.
Illustrated London News. 207.227. S. 1, '45. Effects produced by the bursting of an atomic bomb; illustrations
Illustrated London News. 207:287. S 15, '45. Hiroshima, results of science's latest achievement; photographs with text.
Illustrated London News. 207:311. S. 22, '45. Effects of the atomic bomb· the trial and the grim actuality; photographs with text.
Illustrated London News. 207.344-5. S. 29, '45. Awe-inspiring effects of the atomic bomb dropped on Nagasaki, as seen by a British observer; drawings by G. H. Davis.
Illustrated London News. 207·399-401. O. 13, '45. How the atom can be harnessed for peace; power production by nuclear methods; with diagrammatic drawings by G. H. Davis. M. L. E. Oliphant.
Illustrated London News. 207:670. D. 15, '45. Atom and its isotopes. E. S. Grew.

Illustrated London News. 207·550-1. N. 17, '45 Harnessing the atom to vast projects for the benefit of mankind; diagrammatic drawings.

Independent Woman. 25:34-6. F. '46 What the bomb really blew up; interview with H. Shapley H E. Davis.

Infantry Journal. 58.65-6. Ja. '46. Use of the atomic bomb. R A. Allen

Infantry Journal. 59·23-35. Jl. '46. Military policy and the atomic bomb Bernard Brodie

Information Service (Federal Council of the Churches of Christ in America). 24, no. 34.[1-4]. O. 20, '45 Atom bomb and the future.

Iron Age. 156:112-16. Ag 23, '45. Atomic bomb sidelights.

Iron Age 157:91 My 30, '46 Public wants continued manufacture of atom bombs; Gallup poll

Journal of Chemical Education 22.314-22, 370-9, 418-26 Jl.-S. '45. Periodic system and atomic structure, an elementary physical approach. W. J Wiswesser.

Journal of Chemical Education. 22 481+. O. '45. Atomic bombs and the future E U. Condon.

Journal of Chemical Education. 23 60-5. F '46. Uranium fission: discoveries leading to a chain reaction M. L Eidinoff.
Bibliography, p 65.

Labour Monthly (London). 28 111-15. Ap. '46. Science and the welfare of mankind. S Lilley

Life. 19·17-18+ Ag. 20, '45. Atom bomb and future war. H W. Baldwin.

Life. 19 25-31 Ag. 20, '45. War ends; burst of atomic bomb brings swift surrender of Japanese.

Life. 19 87b-87d, 88-95. Ag 20, '45 Atomic bombs; its first explosion opens a new era

*Life. 19·91+. Ag. 20, '45 Mahattan project F. S. Wickware.

Life. 19·36-9. S 17, '45. What ended the war

Life 19·40. S 17, '45. National security; science, conscription, army-navy merger.

Life 19·27-31. S. 24, '45. New Mexico's atomic bomb crater

Life. 19:27-35. N 19, '45. 36-hour war; Arnold report hints at the catastrophe of the next great conflict.

Life. 20·91-2+. Mr 11, '46 Atom bomb effects, U S Commission analyzes blasts which hit Hiroshima and Nagasaki

London Calling. no. 310 3-4. Ag. 16, '45. Harnessing the power of the universe. Charles Darwin, Geoffrey Taylor.

Look. 10 19-33. Mr. 5, '46. Your last chance, pictures.
Separate. National Committee on Atomic Information. 1749 L St. Washington, D.C.

Machine Design. 17.108. S. '45. What's behind the atomic bomb? H. D. Smyth.

Madison Quarterly. 6:32-8. Ja. '46. Teaching physical sciences in the atomic age. T J. Blisard.

Materials and Methods 22:1054-7. O '45. Materials for producing the atomic bomb. Kenneth Rose.

Mechanical Engineering. 67.672+ O. '45. Atomic engineering? Theodore von Kármán

Same. Journal of Engineering Education. 36.247-9 D. '45; Journal of Applied Physics. 17 2-3. Ja. '46.

Mechanical Engineering 68:11-13+. Ja. '46. Problems we face. L A Hawkins.

Abstract. Machine Design 18 101-2+. Ja. '46.

Mechanical Engineering 68:41-2. Ja. '46. Atomic energy; abstract. R. E Fearon

Mechanical Engineering 68.297-301 Ap '46. Atomic-bomb engineering A C. Klein

Menorah Journal. 33:219-22. O '45. Genesis of the atomic bomb; broadcast Raymond Swing

Metal Progress 48 1102-3. N. '45. Control of explosive atomic energy C. S Smith.

Metal Progress. 48 1313-44. D '45. Atomic power and atomic bombs; a condensation of the Smyth report. R P. Johnson.

Metal Progress. 49 761-9+. Ap. '46. Atomic energy and its implications, round table discussion. C. S Smith and others.

Mining and Metallurgy 26 578-9. N. '45. Observations on the atomic bomb by an A I.M E member who helped make it. C. S. Smith.

Mining and Metallurgy. 26.582-3. N. '45. Metallurgy, morals and the atomic bomb. F. T. Sisco.

Nation 161.154-6. Ag. 18, '45. When H. G. Wells split the atom; a 1914 preview of 1945.

Nation. 161:701-20 D 22, '45. Challenge of the atomic bomb; special supplement containing addresses delivered at annual Nation Associates' forum, December 1-3, 1945.

National Parent-Teacher. 40.19-20, 26-7. Ja -F. '46. Atomic energy and education. G L. Maxwell.

National Review (London) 125 277-9 O. '45 At Hiroshima and Nagasaki.

National Review (London). 125.315-18. O '45. Atomic bomb. Watchman, pseud

National Review (London). 125.379-85. O. '45. Science and sea warfare. H. G. Thursfield.

Natural History. 54.349. O. '45. Man and the atom H. L. Shapiro.

Natural History 54:350-8. O. '45. Inside the atom. Willy Ley.

Nature. 156:382. S. 29, '45. Atomic bomb, activity in Great Britain and the United States leading to its use.

Nature. 156.768-9. D. 29, '45. American work on the atomic bomb project. N. Feather.

Nature. 157:5-7. Ja. 5, '46. Release of atomic energy. M. L. Oliphant.
Erratum. Nature. 157:44. Ja. 12, '46.

Nature. 157:146-51. F. 9, '46 Atomic energy as a human asset; substance of address before American Philosophical Society, November 16, 1945. A. H. Compton

New Republic. 113:240-1. Ag. 27, '45. Atomic and human energy.

New Republic. 113:344-7. S. 17, '45. How the bomb came to be. Bernard Jaffe.

New Republic. 113:504. O. 15, '45 Smyth report. Bernard Jaffe.

New Republic. 113:600-2. N. 5, '45. Strategy in the atomic age. Potomacus.

New Republic. 113:707-9. N. 26, '45. Men who made the A-bomb. Louis Falstein.

New Republic. 113:885. D. 31, '45. Still making bombs.

New Republic. 114:177-80. F 11, '46. Beyond imagination. Philip Morrison.

New Republic. 114:339-41. Mr. 11, '46. Seversky and the bomb. Fletcher Pratt.

New York Times. p. 4. Ag. 7, '45. Statements on development of atomic bomb. H. S. Truman, H. L. Stimson.
Same. International Conciliation. 416:760-3; 764-73. D. '45.

New York Times. p. 10E. Jl. 7, '46. Atom bomb is proved most terrible weapon. H. W. Baldwin.

New York Times Book Review. p. 1+. Mr. 17, '46. Atom bomb versus human race; review of One World or None, ed. by D. Masters and K. Way. R. L. Duffus.

New York Times Magazine. p. 5-7+. Ag. 12, '45. We enter a new era, the atomic age. H. M. Davis

New York Times Magazine. p. 19. S. 2, '45. Atomic prophecy, 1931.

New York Times Magazine. p. 10+. S. 30, '45. Our new concept of the universe. H. M. Davis.

New York Times Magazine. p. 5+. D. 30, '45. 1946. we face our greatest challenge. R. B. Fosdick.

New York Times Magazine. p. 8-9. Je. 9, '46. How to live with the atom; cartoons by S. Price; text by R. B. Wallace.

*New York Times Magazine. p. 7+. Je. 23, '46. Real problem is in the hearts of men; new type of thinking is needed to meet the challenge of the atomic bomb; ed. by M. Amrine. Albert Einstein.

New York Times Magazine. p. 5+. Je. 30, '46. New weapons, menace and warning. H. W. Baldwin.

New Yorker. 21:15-16. Ag. 18, '45. Fateful night; Dr. Dunning's discovery.

New Yorker. 21:48+. S. 29, '45. Atomic city. Daniel Lang.

New Yorker. 21:73-80. D. 1, '45. Contemporaneous memoranda of Dr. Sachs. G. T Hellman.

Newsweek. 26:30+. Ag. 13, '45. Awesome force of atom bomb loosed to hasten Jap surrender.

Newsweek. 26:34+. Ag. 20, '45. New era: the secrets of science.
Newsweek. 26.25. S. 3, '45. Cosmic energy and sea power, together. W. V. Pratt.
Newsweek. 26:37. D. 17, '45. Black lesson of the atom bomb: its awful fury kills even hope, excerpt of testimony by Philip Morrison before the Senate Special Committee on Atomic Energy.
Newsweek. 27:72. F. 11, '46. Nagasaki sick: report on radiation sickness. J. J. Timmes.
Newsweek. 27:60. Mr. 25, '46. Atom dimout.
Newsweek. 27:60+. My. 13, '46. Nuclear leviathan; synchrotron.
Nineteenth Century. 138:112-18. S. '45. Atomic bomb. H. Rowan-Robinson.
Pacific Historical Review. 15 1-30. Mr '46. Social sciences in the National Science Foundation. L. K. Koontz.
Petroleum Engineer. 17:240+. Mr. '46. Uranium—source of atomic energy. G. E. Kidd.
Phi Delta Kappan. 27:221-4. Ap. '46. Consequences of atomic energy. Robert Redfield.
Popular Mechanics Magazine. 69:690-3+. My. '38. Putting the atom to work.
Popular Mechanics Magazine. 85:32-5+. F. '46. On guard against death rays. T. E. Stimson, Jr.
Popular Science Monthly. 147:68. O. '45. Language of atomic power.
Popular Science Monthly. 147·69-73+. O. '45. What's behind atomic power? A. P. Armagnac.
Popular Science Monthly 147:65-9+. D. '45. We can harness the atom. W. L. Davidson, Jr.
Power Plant Engineering. 49 74-7 S. '45. Atomic energy is here; atomic bomb development and its implications for mankind. A. W. Kramer.
Power Plant Engineering. 49:78-84. S. '45. Uranium and atomic energy. A. W. Kramer.
Power Plant Engineering. 49:84-5. S. '45. Atomic bombs and the future. E. U. Condon.
Same. Petroleum Engineer. 16:144+. S. '45; Journal of Chemical Education. 22.481+. O. '45; Diesel Power and Diesel Transportation. 23:1356+. N. '45.
Power Plant Engineering. 49:95-100. O ; 100-4. N.; 99-100+. D. '45; 50:87-92. Ja.; 81-4+. F. '46. Development of atomic energy. A. W. Kramer.
Power Plant Engineering. 50 85-8+. Mr. '46. Effect of the atomic bomb on our civilization. A W. Kramer.
Progressive Education. 23:234. Ap '46. Warning!
Reader's Digest. 47:8-9. O. '45. Blasts that shook the world. J. J. O'Neill.
Reader's Digest. 47.9-11. O. '45. Atom bomb calls for re-study of all our plans for defense. H. W. Baldwin.

Reader's Digest. 47:108-12. D. '45. Let's be realistic about the atom bomb. F. V. Drake
Reader's Digest. 48:121-6. F. '46 Atomic bomb hysteria; study of war destruction in Japan. A. P. De Seversky.
Reader's Digest. 48·125-8. My '46. What the atom bomb would do to us; reply to A. P. De Seversky. Robert Littell.
Same. Infantry Journal. 59 36-7. Jl. '46.
Religious Education. 41 3-5. Ja. '46. Prometheus unbound. Hugh Hartshorne
Review of Scientific Instruments 16:260-2. S. '45. Atomic bomb; abstract of Smyth report
Reviews of Modern Physics 12.1-29 Ja. '40 Nuclear fission. L. A. Turner.
Roads and Streets. 88:99+. S. '45. Evolution of the atomic bomb H. P. Gillette.
Rocket-Jet-Flying. 102.3-5 Winter-Spring '45-'46 Rocketomy; the science of rocketry and atomic power C. P. Lent
Rotarian. 67:8-9+ O. '45. Now that we've burst the atom A. H. Compton.
Saturday Evening Post 213.12-13. S. 7, '40. Atom gives up. W. L. Lawrence.
Saturday Evening Post 218:14-15+. N. 10, '45. How we kept the atomic bomb secret. Joseph Marshall.
Saturday Evening Post. 218.34+ Ja 5, '46. Is the atom terror exaggerated? Lise Meitner tells you what she thinks. George Axelsson.
Saturday Evening Post. 218·9-10+. Ap 13, '46. Is atomic energy the key to our dreams? W. L. Laurence.
Saturday Evening Post. 218·18-19+. Je. 8, '46. How to drop an atom bomb. P W Tibbetts, Jr.
Saturday Evening Post 219·9+. Jl. 13, '46. Your flesh should creep; did our national safety die at Hiroshima? Joseph Alsop and Stewart Alsop.
Saturday Review of Literature. 28·18. O 27, '45. Atomic power in war and peace. A. H. Compton
Saturday Review of Literature. 28 28+. N. 17, '45 Are we making the transition wisely? Eugene Wigner
Saturday Review of Literature. 28.9-11 N. 24, '45. Atomic weapons and the crisis in science. J. R. Oppenheimer.
Saturday Review of Literature. 28:24+. D. 1, '45. Meaning of atomic power. R R Williams.
Saturday Review of Literature. 28·16-17. D 29, '45 Lesson of atomic energy. H. D. Smyth
Saturday Review of Literature 29.15. Ja. 5, '46. Capsules, 1967; fable. J F. Dobie
School and Society. 62:133-4. S. 1, '45 University of Chicago's contributions to the atomic bomb.

School and Society. 62:257-9. O. 27, '45. Atomic energy and the coming revolution in education. L P. Todd
School and Society. 63:405-6. Je. 8, '46. Psychologists advise on the atomic-bomb peril; six-point program of the American Psychological Association.
School Science and Mathematics 45 665-8 O. '45 Atom smashing and its modern applications. R D. Evans.
School Science and Mathematics 46:1-6 Ja. '46 Significance of atomic energy. H. B Haas.
Science. 102:163-5 Ag. 17, '45 Report on the atomic bomb; text H S. Truman.
Same. Current History n s. 9:185-7 S. '45, International Conciliation. 416 760-3. D '45, Metal Progress. 48:475-6 S. '45
Science. 103 65-8. Ja 18, '46. Science for democracy Ward Shepard.
Science 103 289-302 Mr. 8, '46. Neutron, the intermediate or compound nucleus, and the atom bomb. W. D. Harkins.
Science and Society. 10, no. 1:1-16. Winter '46. Era of atomic energy Paul Langevin
Science Digest. 18:17-19. O. '45. Story behind the atomic bomb. Waldemar Kaempffert
Science Digest. 19:9-12 Mr. '46. What an atomic war would be like
Condensed from Wall Street Journal D. 27, '45.
Science Education. 29 240-4. D. '45. Social implications of the introduction of atomic energy. W H. Stickler.
Science Education 30.7-9. F. '46 Atomic bomb and the teacher of science. Phillip Morrison.
Science News Letter. 48.223-4. O. 6, '45. Laws of matter up-to-date. H. M. Davis, comp
Separate. 2p. Science Service. 1719 N. St. Washington 6, D C.
Science News Letter. 49:179-80. Mr. 23, '46. A-bomb effects studied.
Science News Letter. 49.291-2. My 11, '46. New-type atom smasher, synchrotron.
Science News Letter. 49:294 My. 11, '46. Radiation injury study.
Science News Letter. 49 394-5. Je. 22, '46. Background of the atomic bomb Watson Davis.
Scientific American. 161.214-16. O. '39. Two elements for one; splitting the uranium atom. Jean Harrington.
Scientific American. 173:238-41. O '45. Atomic bombs. A. P. Peck.
Senior Scholastic 47:13-14. S. 17, '45. Atomic revolution.
Social Studies. 37:56-60. F. '46. Political education for the atomic age. W. E. Myer.
South Atlantic Quarterly. 45:265-85. Jl. '46. Nuclear fission: a new light on politics. P. M. A Linebarger.
Standard. 32.92-5. Ja. '46 Atomic power and public policy M. L, Cooke.

Steel 117.112-14+. O 1, '45. Facts about atomic energy. A. H. Allen.

Studies (Dublin). 34·449-64. D. '45. Atomic power: past and future. P. J. MacLaughlin.

Survey Graphic. 35·19-23. Ja '46. Year one: atomic age; addresses at meeting in New York City. H D. Smyth and others

Survey Graphic. 35.148+. My. '46. E-MC². Stuart Chase.

Teacher Education Quarterly. 3·47-51 F. '46. Educators and the atomic bomb. E. H. Sloane

Time 46.29-32+ Ag. 20, '45 Atomic age

Time. 46 68. S. 17, '45 Atomic footprint

Time. 47:33. F 25, '46. Lost secrets.

Time. 47 88. F 25, '46 Atomic doldrums.

Town Meeting (Bulletin of America's Town Meeting of the Air). 12, no. 3 1-23. My. 16, '46 Science—salvation or destroyer of mankind? H. C. Urey, W. L. Lawrence, S A Waksman and H. N. Bundesen.

United States News 19 642-5. Ag. 15, '45. Warning to Japan; broadcast, August 9, 1945. H. S Truman.

United States News. 19:28-9 S 7, '45. Atomic force in war and peace: sequel to bombing of Japan.

United States News. 20:28 F. 1, '46. Navy's role in an atomic war; basic plans for meeting and countering possible bomb invasion.

United States News. 20.15-16. Mr. 1, '46. Action behind the spy scare: espionage by all major nations.

United States News. 20:20-1 Mr 1, '46. Will the world disarm? record peacetime forces.

United States News. 20:30-1. Mr 22, '46. Atomic warfare and the Christian faith, excerpts from report of Commission on the Relation of the Church to the War in the Light of the Christian Faith.

United States News. 20 77-9 Ap 12, '45 Need for a strong America; address, April 6, 1946 H S Truman.
Same. Vital Speeches. 12 386-8. Ap. 15, '46.

United States News. 20:19-22. My 31, '46. U S. strategy for next war: atomic reply to aggression.

United States News. 21·63-78. Jl 5, '46 Atomic bomb; first official report on damage to Japan; full text of U S. Strategic Bombing Survey's findings.

United States News 21:63-6. Jl. 26, '46. How U.S can protect itself; conclusions of Strategic Bombing Survey based on analysis of Pacific War.

United States News. 21·28-9 Ag 16, '46. Our defense against the atomic bomb. David Lawrence.

University of Chicago Round Table. 386:1-14. Ag. 12, '45. Atomic force: its meaning for mankind. Reuben Gustavson, Robert Hutchins and William Ogburn

University of Chicago Round Table. 405:1-20 D 23, '45. What about science legislation? Andrew Ivy, Edward Levi and Harold Urey

*University of Toronto Quarterly. 15:256-68. Ap. '46. Atomic energy and world order. Frank Allen.

Virginia Quarterly Review. 22, no. 2:161-78. [Ap.] '46 Time for peace? W. Y. Elliott.

Virginia Quarterly Review. 22, no 2:193-208. [Ap.] '46. Last weapon? Tom Wintringham.

Vital Speeches of the Day. 11.642-5. Ag 15, '45 Warning to Japan; broadcast, August 9, 1945 H. S. Truman.

Vital Speeches of the Day. 11:762-7 O. 1, '45 Story behind the atomic bomb; teamwork among scientists. R. G. Gustavson.

Vital Speeches of the Day 11:767-8 O. 1, '45. Is the use of the bomb justified? F. G. Tyrrell.

Woman's Home Companion. 72.4+ D. '45. Your life in the atomic age. Lise Meitner

World Affairs. 109.99-108 Je '46. Atomic energy, master or servant H. C. Urey.

Yale Review. 35:399-414. Mr. '46. American security and the atomic bomb. Bernard Brodie.

Control: National and International

Books, Pamphlets and Documents

American Association for the United Nations. Control of atomic energy. 1p. The Association 45 E. 65th St. New York 21. S. '45.

Arnold, H H and others. This is the lesson 25p. Plaza Bank. 1230 Olive St. St. Louis 3, Mo Ag '45.

Association of Oak Ridge Scientists at Clinton Laboratories Editorial Committee. Only one way out; statements published in St. Louis Globe-Democrat, November 17-21, 1945. 30p. Plaza Bank 1230 Olive St. St. Louis, Mo.

*Atomic Scientists of Chicago. Atomic bomb. 62p The Scientists 1126 E. 59th St. Chicago. '46.
Bibliography, p. 61-2.

Brodie, Bernard, ed Absolute weapon: atomic power and world order. (Institute of International Studies. Yale University) 214p. Harcourt, Brace & Co. New York. '46.
Review by R. M. Hutchins. New York Times Book Review. p. 6+. Je. 9, '46.

Brodie, Bernard. Atomic bomb and American security. (Memorandum no. 18) 28p. Institute of International Studies. Yale University. New Haven, Conn. N 1, '45.

Campbell, J. A. Atomic bomb. 5p. mim. Publicity Bureau. Oberlin College. Oberlin, O.

Carnegie Endowment for International Peace Committee on Atomic Energy Conference report on international inspection of radioactive mineral production. 15p The Endowment 405 W. 117th St. New York 27, Geological Society of America 419 W. 117th St New York 27 '46.

Carnegie Endowment for International Peace. Committee on Atomic Energy. Utilization and control of atomic energy; a draft convention prepared by the Legal Subcommittee in consultation with other legal, political and scientific experts. 40, ivp. The Endowment. 405 W. 117th St New York 27 Je. '46.

Compton, Arthur H. Atomic power in war and peace. 18p. Plaza Bank 1230 Olive St. St. Louis 3, Mo. O. 5, '45.

Abridged Christian Science Monitor Magazine Section. p. 6-7+. Ja. 12, '46, Saturday Review of Literature. 28 18. O. 27, '45, *Abstracts*. Atomic power seen as a possibility within ten years. Iron Age. 156 171-4. O. 18, '45; Mechanical Engineering 67 850-2. D. '45

*Culbertson, Ely. How to control the atomic threat. 13p. Fight for Total Peace. 16A E. 62d St. New York 21. '45.

Culbertson, Ely. How to win the atomic peace. 2p. Fight for Total Peace. 16A E. 62d St. New York 21.

Reprint from the New Leader, January 12, 1946.

Culbertson, Ely. Must we fight Russia? 62p. John C. Winston Co. Philadelphia. '46.

Davis, Watson. Atomic power plants of the future. (Beyond victory program no. 122) 6p mim. World Wide Broadcasting Foundation. 598 Madison Ave. New York 22. '45.

*Dresden, Arnold. Scientific spirit in international relations. 11p. mim. The Author Swarthmore College. Swarthmore, Pa N '45.

Fosdick, Raymond and Eichelberger, C. M. Can the United Nations control atomic energy? (Beyond victory program no. 120) 5p. mim. World Wide Broadcasting Foundation. 598 Madison Ave. New York 22. '45.

Gideonse, Harry D. and others. Politics of atomic energy. 56p. Woodrow Wilson Foundation. 45 E. 65th St. New York 21. Mr '46.

Contents: Introduction. H. D. Gideonse; Challenge of 1946. R. B. Fosdick; If international action fails. W. F. Ogburn; Toward the world state F. L. Schuman.

Hutchins, Robert M. Atomic bomb versus civilization. (Human events pam. no 1) 14p. Human Events Inc. 608 S. Dearborn St. Chicago 5. D. '45.

Same. Association of American Colleges Bulletin. 32:34-42. Mr. '46; National Education Association. Journal. 35:114-17. Mr. '46.

Huxley, Aldous. Science, liberty and peace. 86p. Fellowship of Reconciliation. 2929 Broadway. New York 25; Harper & Bros. New York. Mr. '46.

King, Judson Facing 1946 and the atomic age. (Bulletin no. 220) 7p. mim. National Popular Government League. 23 Columbia Ave. Washington 12, D.C. D. 19, '45.

Levenstein, Aaron Atomic age, suicide, slavery or socialism? 39p. Socialist Party 303 4th Ave. New York 10. n d.

McMahon, Brien Challenge of atomic energy (Beyond victory program no. 119) 5p. mim World Wide Broadcasting Foundation. 598 Madison Ave. New York 22 '45.

McMahon, Brien and others. Foreign policy and the atom. (Program 62) 18p National Broadcasting Co. 30 Rockefeller Plaza New York 20. Ap. 20, '46

McNair, John Socialist life or atomic death 19p. Independent Labour Party 318 Regents Park Rd London N3; Universal Distributors Co. 38 Union Sq New York. Mr. '46

Nathanson, Jerome. Atomic power and public policy. 9p. New York Society for Ethical Culture. 2 W. 64th St. New York. Ap. 7, '46

National Association of Manufacturers. NAM believes atomic energy bill serious threat to private enterprise, free competitive system (NAM News. Sec 2) [2p.] The Association 14 W. 49th St. New York 20. Jl 13, '46.

National Committee on Atomic Information. Questions and answers about atomic energy 32p. The Committee 1749 L St. Washington 6, D.C. '46.

National League of Women Voters. Progress report on atomic energy. (Brief for action. Pub. no 54) 7p. The League. 726 Jackson Pl. Washington 6, D.C. F. 14, '46.

National League of Women Voters What to do with atomic energy? 6p. mim. The League. 726 Jackson Pl. Washington 6, D.C. N. 2, '45.

National Policy Committee. Control of the bomb, report of a session of the Minnesota Policy Committee. (Report no. 36) 20p The Committee. 1202 National Press Bldg. Washington 4, D.C. Ja. 10, '46.

National Policy Committee. Memorandum of the Washington dinner on the bomb and the world. (Memoranda no. 43) 21p. The Committee. 1202 National Press Bldg. Washington 4, D.C. '45.

O'Connor, Tom. Atoms and you. 23p. Pamphlet Press. 27 E. 67th St. New York 21. '45.

Phelps, Edith M. ed. Ownership of patents on atomic energy. *In* University Debaters' Annual, p. 115-63 H. W. Wilson Co. New York. '46

Reves, Emery. Anatomy of peace. 275p. Harper & Bros New York. '45.

Roberts, Owen J. and others. This is our hour; open letter to President Truman on the atomic bomb. 13p. Plaza Bank. 1230 Olive St. St. Louis 3, Mo '45.

Shapley, Harlow. Scientist looks at atomic energy. (Beyond victory program no. 121) 6p. mim. World Wide Broadcasting Foundation 598 Madison Ave. New York 22. '45.

Swing, Raymond. Baruch plan sabotaged; radio transcript July 19, 1946. 3p American Broadcasting Co. 30 Rockefeller Plaza. New York 20.

Swing, Raymond. [A series of radio broadcasts on the atomic bomb, August 1945-date] mim. American Broadcasting Co. 30 Rockefeller Plaza. New York 20.

Swing, Raymond. In the name of sanity. 116p. Harper & Bros. New York. '46.

United States Congress. Act for the development and control of atomic energy. (S 1717) (Public law 585, 79th Congress) 22p. [Approved August 1, 1946] Supt. of Docs. Washington 25, D.C.

United States. Department of State. International control of atomic energy; radio discussion Dean Acheson, Vannevar Bush and Larry LeSueur. (Press release no. 274) 18p. mim. Ap. 23, '46.

United States. Department of State. Report on the international control of atomic energy; prepared for the Secretary of State's Committee on Atomic Energy by a Board of Consultants, D. E. Lilienthal, chairman. (Pub. no 2498) 61p Supt of Docs. Washington 25, D.C. Mr 16, '46.

Same. 8p St Louis Post-Dispatch Ap 7, '46; *Same with preface* by I. I. Rabi 55p Doubleday & Co Garden City, N.Y. '46; *Abridged.* Bulletin of the Atomic Scientists 1 2-9 Ap. 1, '46; Department of State Bulletin. 14.553-60. Ap. 7, '46

*United States. Department of State. United States atomic energy proposals; statement of United States policy on control of atomic energy as presented by Bernard M. Baruch to United Nations Atomic Energy Commission, June 14, 1946 (United States and United Nations report series no. 2) (Pub 2560) 12p. Supt. of Docs. Washington 25, D.C.

Same Department of State Bulletin. 14 1057-62 Je 23, '46; Congressional Record. 92:(daily)A3703-5. Je. 17, '46; New York Times. p. 4. Je. 15, '46; 8p. mim. American Association for the United Nations. New York.

United States. House. Committee on Military Affairs. Atomic energy; hearings, October 9 and 18, 1945, on H. R. 4280. 141p. 79th Congress, 1st session. Supt. of Docs. Washington, D.C. '45.

United States. House. Committee on Military Affairs. Atomic energy act of 1945, report [and additional minority views] to accompany H. R. 4566. 2pts. House report. 1186. 79th Congress, 1st session. Supt. of Docs. Washington, D.C. '45.

United States. Library of Congress. Legislative Reference Service. Atomic power: issues before Congress, Eilene Galloway. (Public Affairs bulletin no. 44) 123p. mim. Library of Congress Publications Office. Washington 25, D.C. '46.

United States Senate. Committee on Military Affairs. Hearings on science legislation (S. 1297 and related bills); hearings before a subcommittee October 8, 1945-March 5, 1946. pursuant to S. Res. 107 (78th Congress) and S. Res. 146 (79th Congress). 6 parts. 79th Congress, 1st Session. Supt of Docs. Washington, D.C. '45, '46.

United States Senate Special Committee on Atomic Energy. Atomic energy act of 1945, report to accompany S. 1717, submitted by Mr. McMahon. (Senate report no. 1211) 125p. 79th Congress, 2d session. April 19, '46.

*United States Senate Special Committee on Atomic Energy. Atomic energy: hearings, November 27, 1945-February 15, 1946, pursuant to S. Res. 179. 5 pts 573p. 79th Congress, 2d session '45, '46

*United States. Senate. Special Committee on Atomic Energy. Atomic energy act of 1946; hearings, January 22-April 8, 1946, on S. 1717. 5 pts 539p 79th Congress, 2d session Supt. of Docs. Washington, D.C. '46

*United States Senate. Special Committee on Atomic Energy. Essential information on atomic energy (including a glossary and bibliography), pursuant to S. Res. 179. (Committee monograph no. 1) 79th Congress, 2d session 94p Government Printing Office Washington, D C '46.
*Chronological table p 41-4

Walker, Sydnor H, ed. First one hundred days of the atomic age, August 6-November 15, 1945. 72p. Woodrow Wilson Foundation 45 E. 65th St. New York 21. D '45.

Weissbourd, Bernard. State Department report on control of atomic energy; a brief summary. 11p National Committee on Atomic Information. 1749 L St. Washington 6, D C Mr. 29, '46.

Woodward, E. L. Some political consequences of the atomic bomb. 22p. Oxford University Press. New York. '46

PERIODICALS

Academy of Political Science. Proceedings 21.563-72. Ja. '46. Atomic control. H. E Stassen.
Same with title From war to peace. Commercial and Financial Chronicle 162·2369+. N. 15, '45; United States News. 19.32-4. N. 16, '45.

American Affairs. 7:217-19. O '45. Drama of man in the atomic age. R. J. G. Boothby.

American Association of University Professors Bulletin 31:681-96. D. '45. Some reflections on the progress of science and the Magnuson-Kilgore bill Theodore Koppanyi.

American Forum of the Air. 7, no 41:1-15. O. 16, '45. Should we internationalize the atomic bomb? Brien McMahon, Norman Cousins, H. E. Capehart and W B Ziff.

American Forum of the Air. 8, no. 11:1-15. Mr. 26, '46. Atomic bomb —civilian or military control. E. C. Johnson, T. C. Hart, J. C. O'Mahoney and J. C. Stearns.

American Journal of International Law. 39 788-90 O '45. Basic energy and international law. P. B. Potter.

American Journal of International Law. 40.161-5 Ja '46. Atomic bomb. Edwin Borchard.

American Journal of International Law. 40·165-7 Ja. '46 International control of the atomic bomb. Edgar Turlington.

American Petroleum Institute. Proceedings 25 (1):60-5 '45. Research, industry, and government B. K Brown.

American Scholar. 15, no 1:13-24. [Ja.] '46. Old Adam and the atom. James Marshall.

Also separate. American Scholar. 5 E. 44th St. New York 17.

American Scholar. 15, no. 2:147-79. [Ap.] '46. Life with the atom; American Scholar forum.

Science and secrecy. L. N. Ridenour; Liberal of 1946. G. W. Johnson, Politics is peace. Nathaniel Peffer, Reality of utopia. Erich Kahler.

American Teacher. 30.17-19. Ja. '46. Education—defense against atomic bombs. Aaron Novick

Annals of the American Academy. 242:46-7. N. '45. Challenge of advancing technology B. J. Stern

Antioch Review. 5:511-23. D. '45. Social control of atomic energy. O. S. Loud.

Atlantic Monthly. 176:43-5 N. '45. Einstein on the atomic bomb; ed by R. G. Swing.

Abridged. Reader's Digest. 47·7-10. D. '45, Metal Progress. 49:358. F. '46 *Separate.* 2p World Community. Vol. 6, no. 6. D. '45. World Community Movement. 406 E. Center St. Tucumcari, N.M.

Atlantic Monthly. 177·39-42. Ja. '46 Atomic bomb and world government; reply to A Einstein. Sumner Welles.

Abstract. Metal Progress. 49 359. F. '46, *Abridged with title* Only way to world government. Readers' Digest. 48 97-100. Mr. '46.

Atlantic Monthly. 177:53-60. Mr. '46. Timetable for world government. T. K. Finletter.

Separate. [8p.] Americans United for World Government 1860 Broadway. New York 23.

Atlantic Monthly. 178.37-45. Jl. '46. Stopping the armament race. D E. Lilienthal, H. DeW Smyth, Cord Meyer, Jr.

Aviation. 44.103-4. D. '45. Controlled atoms or controlled lives. J. H. McGraw, Jr.

Aviation News. 5:9. Ap. 22, '46. Army, navy strongly criticize patent provisions of science bill. William Kroger.

British Speeches of the Day. 3:669-83. D. '45. President Truman's declaration; extracts from speeches in House of Commons, November 7, 1945. Winston Churchill, Clement Davis and Ernest Bevin.

Business Week. p 17-18. N. 10, '45. Atom control: another try.

Business Week. p. 20-1. Ja. 12, '46 Science speaking; having headed off the May-Johnson bill, junior atom-smashers are making national drive for McMahon measure.

Business Week. p. 19-20. Mr. 16, '46. A-bomb warning; army reasserts its authority.

Business Week. p. 16-17. Je. 22, '46. What's in atoms? industrial claim-stakers in field.

Business Week p. 112. Jl. 6, '46. Atom control: the door is still open.

Call. 13·1+. F 4, '46 Socialist atomic energy bill introduced by Rep. Celler; H R 5230
Call. 13 1-2. Mr 11, '46. Control of atomic energy must not go to the militarists.
Call 13·2 Mr 11, '46. Comparative summary of Celler bill [H.R. 530] with Senate bills for control of atomic energy
Chemical and Engineering News 23.1638. S. 25, '45. Patent rights on atomic bomb transferred to U S. by industry.
Chemical and Engineering News. 23 2069. N. 25, '45. Will the atomic pact work?
Chemical and Engineering News. 23.2086-92 N 25, '45 Atomic energy legislation; texts of the May-Johnson bill H R. 4566 and S. 1463, the Ball bill S. 1557, and the McMahon bill S. 1359.
Chemical and Engineering News. 24·363-70. F. 10, '46. Atomic energy legislation.
Chemical and Engineering News 24:786-9 Mr. 25, '46. Science legislation, revised Kilgore-Magnuson bill, S. 1850.
Chemical and Engineering News. 24·1350-2. My. 25, '46. Atomic explosives J. R Oppenheimer.
Chemical and Metallurgical Engineering. 53:117+ Mr. '46. Engineering representation is an A-bomb must, defect in bill S. 1717.
Christian Century. 62:1279-81. N 21, '45 What to do with the atom.
Christian Century. 63·233-5. F. 20, '46. Is world disaster inevitable? T. R. Hogness
Christian Century 63:297-9 Mr. 6, '46 Atom and world community C. E. Merriam
Christian Century 63:390-1. Mr. 27, '46 Militarized America.
Christian Century. 63:455-7. Ap 10, '46. Theology and the bomb.
Christian Century 63·796. Je. 26, '46. Atomic charter bars one-power veto; atom plan marks step to world government.
Christian Science Monitor 38.1+. My. 4, '46. U.N. rule of atom energy pictured as years away.
Christian Science Monitor 38:1. S. 7, '46. U.S. formula held atomic key to peace
Christian Science Monitor Magazine Section. p. 3. Jl. 27, '46 Atomic peace or atomic war? Roscoe Drummond.
Churchman. 159:9 O. 15, '45. Doom or dawn? atomic bomb and the world's obsolete nationalisms. J A. Leighton.
C I O News. 9:7. Mr. 18, '46. Atomic bomb, a fascist menace.
Collier's 116 18-19+. S. 29, '45. Deliverance or doom? Philip Wylie.
Commercial and Financial Chronicle. 162:1746. O. 11, '45. President urges legislative control of atomic power; House group asks secrecy.
Commercial and Financial Chronicle. 162:2497+. N. 22, '45. Atomic bomb and future peace. J. F. Byrnes.

Commercial and Financial Chronicle. 162·2922. D. 13, '45. Senate group hears recommendations on atom bomb control
Commercial and Financial Chronicle. 163:1214+. Mr. 7, '46. Sinews of peace; address at Fulton, Mo, March 5, 1946. Winston Churchill.
Commercial and Financial Chronicle 163.3342. Je. 20, '46. UN attempting atom control; Baruch and Gromyko present plans.
Commercial and Financial Chronicle. 164:202+. Jl. 11, '46. Science and world order. R. G. Gustavson.
Common Sense. 14.3-7. D. '45. Atomic power and world peace. Ely Culbertson.
Commonweal 44:275-6. Jl. 5, '46. Atom; the Baruch plan.
Congressional Digest. 25·131-60 My. '46. What Congress is doing to solve the problem of atomic control; with pro and con discussion.
Congressional Notebook. 3, no. 20:1-8. Mr. 16, '46. Congress and science.
Congressional Record 91:(daily)9478-9, 9524-5. O. 3, '45. Development and control of atomic energy; message to Congress, October 3, 1945. H. S. Truman.
Same. International Conciliation. 416.774-8. D. '45; Vital Speeches of the Day 12:8-10. O. 15, '45.
Congressional Record. 91:(daily)10140-3. O. 24, '45. Creation of a world republic. G. H. Taylor.
Separate. 4p. The Author. Senate Office Bldg. Washington, D C.
Congressional Record. 91.(daily)10287-8. O. 29, '45. Address on U.S. foreign policy, Navy Day, October 27, 1945. H. S. Truman.
Same. Vital Speeches of the Day. 12:66-8. N. 15, '45; International Conciliation 416·779-86. D '45
Congressional Record 91:(daily)10987-8. N. 19, '45. Truman-Attlee-King statement.
Same. Commercial and Financial Chronicle 162.2621. N. 29, '45; British Speeches of the Day. 3:688-9. D. '45, Chemical and Engineering News. 23:2197. D. 10, '45; American Journal of International Law. 40.sup.48-50. Ja. '46; Current History. n s.10:62-3. Ja. '46; *Same with editorial comment.* Nature 156 609-10, 615. N. 24, '45
Congressional Record 91:(daily)A5781-5. D. 10, '45. Science and the government. H. M. Kilgore.
Same. Science 102 630-8. D. 21, '45.
Congressional Record. 91:(daily)A6099-6101. D. 19, '45. Resolution on atomic-energy control; submitted by R. S. Mulligan and members of the National Academy of Sciences.
Congressional Record. 92:(daily)442-59. Ja. 28, '46. Plea for world disarmament; remarks in Senate. M. E. Tydings.
Congressional Record. 92:(daily)A1009-13. F. 26, '46. Petition to the General Assembly of the UNO for amendment of the charter.
Congressional Record. 92:(daily) A1118-19. Mr. 1, '46. Brotherhood or bombs, which? F. T. Wilson.
Congressional Record. 92.(daily)A1227-8. Mr. 6, '46. Control of atomic bombs imperative. H. W. Baldwin.
Congressional Record. 92:(daily)A1282. Mr. 8, '46. General Groves' aims on control of atomic energy questioned. G. F. Eliot.

Congressional Record. 92:(daily)A1403-4. Mr. 13, '46. Comparative summary of Celler bill H. R. 5230, with Senate bills for control of atomic energy. Emanuel Celler.

Congressional Record. 91:(daily)A1548-9. Mr. 19, '46. Control of atomic energy. Brien McMahon.

Congressional Record. 92:(daily)A1652. Mr. 21, '46. Civilian control of atomic energy; emergency conference in House Office Building, March 21. Chet Holified.

Congressional Record. 92:(daily)A1744-8. Mr. 26, '46. Role of United Nations in world peace. A. H. Vandenberg.

Congressional Record. 92:(daily)A1782-3. Mr. 27, '46. Control of atomic energy. Jerry Voorhis.

Congressional Record. 92:(daily)A1947-8. Ap. 1, '46. Battle of the atom. W. G. Andrews.

Congressional Record. 92:(daily)A2037. Ap. 4, '46. Atomic statesmanship; editorial from Washington Post.

Congressional Record. 92:(daily)A2054. Ap. 5, '46. Atomic policy; editorial from New York Herald Tribune.

Congressional Record. 92.(daily)3577-8. Ap. 11, '46. International control of atomic energy. J. W. Fulbright.

Congressional Record. 92:(daily)A2288-91. Ap. 15, '46. Atomic energy and human welfare J. C. Stearns.

*Congressional Record 92.(daily)A3703-5. Je. 17, '46. Atomic energy control. B. M. Baruch.

Same. 8p. mim. American Association for the United Nations. 45 E. 65th St. New York 21.

Congressional Record. 92:(daily)A3830-1 Je. 21, '46. Russia and the atom; editorial from Washington Post.

Congressional Record. 92:(daily)A3903-4. Je. 24, '46. Controlling the atom bomb; editorials.

Congressional Record. 92:(daily)A4401-2. Jl. 16, '46. Patent provisions of S. 1717. C. C. Henry.

Congressional Record. 92:(daily)9260-9. Jl. 16; 9378-89, 9390-403. Jl. 17; 9471-514. Jl. 18; 9591-604, 9605-21. Jl. 19; 9672-89. Jl. 20, '46. Development and control of atomic energy; House debate.

Congressional Record. 92:(daily)10405-11. Jl. 27, '46. Atomic Energy Act of 1946; text of S. 1717 [as adopted].

Current History n.s.9:293-8. O. '45. Atomic bomb, key to the international sanction. E. D. Ellis.

Current History. n.s.9:401-5. N. '45. Atomic bomb and the post-war world. T. H. Thomas.

Debaters' Digest. 20:6. Ja. '46. Should we keep the atomic bomb secret? W. B. Ziff; C. B. Luce.

Department of State Bulletin 14·19-20. Ja. 6 and 13, '46. Atomic energy proposal; resolution for the establishment of a commission to deal with control of atomic energy based on proposals drawn up by Moscow Conference of Foreign Ministers
Department of State Bulletin 14:146 F. 3, '46 General assembly of the United Nations, statement by the Secretary of State on control of atomic energy.
Department of State Bulletin 14·198 F 10, '46. General Assembly of the United Nations; resolution on atomic commission
Department of State Bulletin. 14:668 Ap 21, '46 Report on denaturing of atomic explosives. L W Alvarez and others.
Same. 4p. U.S Department of State Washington D.C. Ap. 9, '46
Department of State Bulletin. 14.774-7 My 5, '46 International control of atomic energy, excerpts from radio discussion, April 23, 1946. D G. Acheson and Vannevar Bush
Department of State Bulletin. 15 96-106 Jl 21, '46. U.S memoranda on control of atomic energy
Same. National Committee on Atomic Information News Letter [12p] Ag. 19, '46
Diesel Power and Diesel Transportation. 23 1356+. N '45 Atomic bombs and the future. E. U Condon.
Dun's Review. 54:11-15+ Ja. '46. Science and post-war prosperity. H. M Kilgore
Economist (London). 149.256-7. Ag 25, '45. Controlling the atom
Economist (London). 149 737-8 N. 24, '45. Atom of discord
Economist (London). 150·697-8 My. 4, '46 Atomic progress report.
Same. Iron Age. 157 103+. My. 16, '46
Economist (London) 150.995-6 Je. 22, '46 Atomic plan
Editorial Research Reports. 2, no. 15.273-89. O 23, '45. Government and science. F P. Huddle
Editorial Research Reports. 1, no 16.277-93. Ap. 24, '46. Control of atomic energy. F P. Huddle.
Electrical Engineering. 64:464-5. D '45 Engineers testify at Senate hearings on science legislation.
Electrical World. 125.67-8. Mr. 30, '46. Diluted atomic power use, suggestion for generation
ETC. a Review of General Semantics 3 81-91 Winter '46. International control of atomic energy. Melvin Freedman.
Federal Union World. 7:1-2. S. '45. Safety from atom bomb seen in federal union Neal Potter and others.
Federal Union World. 7:1+ N. '45 Atomic scientists urge need for world government
Fellowship. 11:167-70. O. '45. Atomic bomb and the American dream. A. J. Muste.
Foreign Affairs. 23:378-87. Ap. '45. Science and foreign policy. G. F. Eliot.
Foreign Affairs 24:591-609. Jl. '46. Atomic energy and American foreign policy. C. P. Haskins.

Foreign Policy Bulletin 24·2-3. O 12, '45 Truman takes first steps toward control of atomic power G. S. McClellan
Foreign Policy Bulletin 25:4. Mr 1, '46. U.S delay on atomic policy contributes to world unrest Blair Bolles.
Foreign Policy Bulletin. 25 4. Ap. 5, '46. Atomic energy report points way to international control.
Foreign Policy Bulletin 25.4. Jl. 5, '46 Will Bikini tests strengthen Baruch's efforts to curb veto? Blair Bolles
Foreign Policy Reports. 21:293-4. Ja 15, '46. Has atomic bomb altered U.S foreign policy? V. M. Dean
Foreign Policy Reports. 22 82-92. Je. 15, '46 Atomic energy in international politics. H. C Urey
Fortnightly. 164 (n.s.158):247-52 O '45. Physics and politics. W. T. Wells
Fortune 32 170-1+. N '45 Military security and the atomic bomb. L N Ridenour
Forum 104.348-52 D '45 U.S. control of atomic energy.
Forum 106:28-32. Jl. '46 Atomic legislation. Constance Tuttle
Free World 10·25-8. O. '45. World government vs national sovereignty, atomic bomb makes problem urgent. Louis Dolivet.
Free World. 10.21-3 N. '45. Primer for world government. Louis Dolivet.
Free World. 10·26-31. D '45. Why a world republic; with text of Senate resolution 183 G H. Taylor
Free World. 10 42-4. D '45. Scientists have no illusions; only world government can control atomic power. R D. Present.
Free World. 10:44-5. D '45. Borrowed time; dangers of the atomic age. Michael Straight.
Free World. 11 40-1 Ja. '46 Control of atomic energy. F. C. McKee.
Free World. 11 18-22. Mr. '46 Fascism, atomic power, and UNO. Max Ascoli
Free World. 11.58-60. Ap. '46 Hold that atom! Livingston Hartley.
Free World. 11:55-7. My. '46. Science nucleus of world state; proposal for a world research council, under the United Nations charter. Albert Guerard
Free World. 11:12-13 Je. '46. Atoms for peace. Livingston Hartley.
Harper's Magazine. 192:204. Mr '46. Bomb and the opportunity. H. L Stimson.
Same. Congressional Record. 92:(daily) A1379-80. Mr. 12, '46
Harper's Magazine 192 425-31. My. '46. Can atomic energy be controlled? J. M. Jones.
Industrial Marketing. 30:51+. S. '45. Patent study involves national security. S. E. Cohen.
Information Service (Federal Council of the Churches of Christ in America). 25, no. 16:[1-4]. Ap. 20, '46. Acheson-Lilienthal report.

Information Service (Federal Council of the Churches of Christ in America). 25, no. 17·[1-2]. Ap. 27, '46 Atomic energy and a world state.
*International Conciliation. 416:749-823 D '45. Atomic energy and American policy, official and unofficial pronouncements.
International Conciliation. 417:40-8. Ja. '46. United Nations and the atomic bomb Arthur Salter
Labor and Nation 1:44-6. D '45. International control of atomic power is essential to world peace. Horst Mendershausen
Ladies' Home Journal. 62·6+. O. '45. Atomic science and world organization Dorothy Thompson
Lawyers Guild Review. 5.311-14. S.-O. '45. Atomic energy in international and constitutional law. Committee on International Law and Relations, National Lawyers Guild
Life 19 36. O 29, '45. Bomb; need for its political equivalent
Life. 19.45-6+. O. 29, '45. Atomic scientists speak up; no secrecy in atomic bomb and no defense against it. D. L Hill and others.
Life 19.36. N 26, '45 No miracles
Life. 20.36. Ap 15, '46 Atomic spring; State Department report.
Materials & Methods. 22.1719+. D '45 Atomic energy control a problem for engineers
Mechanical Engineering. 68 454-5. My. '46. One world or none, a report to the public on the full meaning of the atomic bomb; ed by D. Masters and K Way; review by N. J. Padelford
Nation. 161·389-90. O. 20, '45. Atomic isolationism.
Nation. 161:488. N. 10, '45. Britain and the bomb. Aylmer Vallance.
Nation. 161·511-12. N. 17, '45. Russia and the bomb. Freda Kirchwey.
Nation 161.515-16. N. 17, '45. Scientists of the world, unite! Richard Schlegel.
Nation 161.541-3 N. 24, '45. Bomb is a world affair. King Gordon.
*Nation. 161:650-2 D. 15, '45. Plan or perish; address at Nation Associates forum, December 3, 1945. H. J. Laski.
Same. Atomic energy and free enterprise. Commercial and Financial Chronicle 162·2699+. D 6, '45.
Nation. 161:705-8. D. 22, '45. Soviet Union and the bomb. H. G Douglas; M. J. Coldwell, Walter Millis.
Nation. 161:712-17 D. 22, '45. Problem of control. E A Mowrer, T. K Finletter; C. G. Bolte; L. N. Ridenour.
Nation. 162:187-9. F. 16, '46. Washington's atomic war. Tris Coffin.
Nation 162·247 Mr. 2, '46. Fruits of suspicion.
Nation. 162·256-7. Mr. 2, '46. Atoms won't wait. L N. Ridenour.
Nation. 162·333-4. Mr 23, '46. Army and the atom.
Nation 162.418-19. Ap. 13, '46. Atomic report: second reading. I. F Stone.
Nation. 162:454-5. Ap. 20, '46. McMahon bill. I. F. Stone.
Nation. 163·735-6. Je. 22, '46. Atom in a divided world.

Nation. 162:771-2. Je 29, '46 Soviet dilemma.
National Petroleum News 37, pt 2·R579-81+. Ag 1, '45 Congress asked to continue government control of research in peace times.
National Petroleum News. 38·50+. Mr. 6, '46 Science foundation bill compromise between federal setup and one directed by scientists.
Nature. 156 153. Ag. 11, '45. Atomic energy. an international responsibility
Nature. 156:401-5. O. 6, '45. International science co-operation service.
Nature. 156.457-60. O. 20, '45. Science and national defence.
Nature. 157:57-60. Ja. 19, '46. Implications of atomic energy.
New Jersey Municipalities. 24:25-9. Ap. '46. Does the atomic bomb doom the modern city? Louis Wirth.
New Republic. 113:433-5 O 1, '45 Congress grapples with science. M. L. Cooke
New Republic. 113:555-6. O. 29, '45 Internationlize atomic energy!
New Republic. 113:663. N 19, '45. British appeal on atomic energy. Raymond Blackburn.
New Republic. 113.691-2. N. 26, '45. Sixty days to war or peace!
New Republic. 114.119-21 Ja. 28, '46. Atomic power: next steps. Clarke Williams.
New Republic 114.299-300. Mr. 4, '46. World made for war.
New Republic. 114:309-10. Mr. 4, '46 Save the McMahon bill!
New Republic. 114·366 Mr 18, '46. Keep atomic energy free! H. G. Douglas.
New Republic. 114·399-400. Mr. 25, '46 Plea for atomic freedom. Aaron Novick.
New Republic 114:431 Ap. 1, '46. Atomic scrub team.
New Republic 114:461-2. Ap 8, '46. Three cheers; State Department consultants' report
New Republic 114.465-6 Ap. 8, '46. First atomic plan; report of State Department's consultants on international control of atomic energy Alfred Friendly.
New Republic. 114·494-5. Ap. 15, '46. Civilian atomic control
New Republic. 114 748-9. My. 27, '46. Atomic control stalled
New Republic. 114.851-2 Je. 17, '46. America, UN and the atom.
New Republic. 114:915-16. Jl. 1, '46. United Nations and atomic control.
New Statesman and Nation. 30·85. Ag 11, '45. Who owns omnipotence?
New Statesman and Nation. 30.122. Ag. 25, '45. Frankenstein's problem. Ritchie Calder.
New Statesman and Nation. 30·291 N. 3, '45. Facing the armed peace.
New York Herald Tribune. Mr. 3, '46. General Grove's aims on control of atomic energy questioned G. F. Eliot.
Separate. 1p. Association of Oak Ridge Scientists. Box 1251. Oak Ridge, Tenn.

New York Times. p. 14. Mr 6, '46. Control of atomic bomb imperative. H. W. Baldwin
Same Congressional Record. 92 (daily) A1227-8. Mr. 6, '46
New York Times. p 5E. Je. 16, '46. Congress and Kremlin hold key to atom plan James Reston.
New York Times. p 8E. Je. 16, '46. Atomic energy control. F. C McKee
New York Times. p. 4. Je. 19, '46 Military put back into atomic plans; House group amends McMahon bill.
New York Times p. 4. Je. 20, '46. Proposals to control atomic energy; principal speeches before United Nations Atomic Energy Commission, June 19, 1946 General McNaughton, Alexander Cadogan, *A. A. Gromyko.
Same. World Report. 1 44-7. Jl 4, '46.
New York Times. p 8E. Jl. 7, '46. Atomic plans weighed. Leo Gross
New York Times Magazine. p. 8+. S 2, '45. Challenge: one world or none. R B Fosdick.
New York Times Magazine p 5+. N 11, '45. Atomic bomb. the facts and the issue. H. M Davis.
New York Times Magazine. p. 5+. Ja. 13, '46. How can we prevent atomic war? E L. Woodward
New York Times Magazine. p 9+ F. 24, '46. What kind of control for atomic energy? Brien McMahon.
New York Times Magazine. p. 7+. Je. 9, '46 Atom bomb as a great force for peace. J R Oppenheimer.
Newsweek. 26:30-1. O. 1, '45. How not to end the world.
Newsweek. 26:35-6. O. 22, '45. Keeping the push button
Newsweek. 26:33. O. 29, '45. Can't keep it with you; hearings on the May-Johnson bill.
Newsweek. 26:42, 43. N. 12-19, '45. Our gropings on the atom. E K. Lindley.
Newsweek. 26.33-5. N. 19, '45. Russian aims the question mark in talks on controlling the atom.
Newsweek. 26:33-4 N. 26, '45. Western eyes focus on Russia for next move in atom control
Newsweek. 26 61. D. 10, '45. Should we outlaw the atomic bomb in war? W. V. Pratt.
Newsweek. 27:25. Ja. 7, '46. Atom twins. security and disclosure. E. K. Lindley.
Newsweek. 27:29-30. Ja. 7, '46. Atom catches.
Newsweek. 27:26. F. 11, '46. Mr. Truman on atom law. E. K. Lindley.
Newsweek 27:23-4. Je. 24, '46. Bomb: the U.S. will yield its secret, if.

Newsweek 27 30. Je. 24, '46. Mr. Baruch on the atom. E. K. Lindley.

Phi Delta Kappan 27:34-6. O. '45 Should we keep atomic energy secret? R. G Gustavson; W F Ogburn.

PM 6:2. Mr. 8, '46. How the army's hush-hush can ruin us. A. H. Uhl.

Political Affairs. 25:713-23. Ag. '46. Atomic energy—for war or peace. Joseph Clark.

Political Quarterly. 17:12-24. Ja. '46 Britain in the atomic age. Leonard Woolf.

Reader's Digest. 47:14-16. N. '45. World government or world destruction? Stephen King-Hall.

Reader's Digest 48:109-17 F. '46. World government is the first step Emery Reves.
Separate. 4p. World Federalists. 29 E 28th St. New York 16.

Review of Politics 8 147-67. Ap. '46. Atomic bomb; political hopes and realities. S T. Possony

Review of Scientific Instruments. 16:330-2. N. '45. Public relations of the atom.

Review of Scientific Instruments 16:388-9. D '45. Atomic Scientists of Chicago answer questions on atomic bomb.

Review of Scientific Instruments. 17.165-6 Ap. '46. Recommendations on release of atom bomb information. Committee on Declassification.

Review of Scientific Instruments. 17:206-8. My. '46. Public relations of the atom. November 1945-April 1946.

Reviewing Stand (Northwestern University on the Air). 5, no. 23:1-12. N. 11, '45. Control of atomic energy. Ovid Eshbach, Malcolm Dole, Marshall Dimock and J. H. McBurney.
Bibliography, p 10-12.

Rotarian. 67:14-17. N. '45. Atomic bomb: should the United Nations Security Council control it? Norman Angell, H. W. Sumners.

Rotarian. 67.2. D. '45. Control atomic-bomb ores. H. P. Pearson.

Rotarian. 68·11+. Ja. '46. Atomic bomb and the price of peace. William Beveridge.

Rotarian. 68:11+. Je '46. Ideals and the bomb. Ernest Dimnet.

Round Table (London). 36:9-14. D '45. United Nations and the atomic bomb.

Saturday Evening Post. 218 128. O 20, '45. Long, hard road to world order.

Saturday Evening Post. 218:120. Ap. 27, '46. Atom argument isn't so simple.

Saturday Review of Literature. 28:5-9. Ag. 18, '45. Modern man is obsolete. Norman Cousins.
Abridged. 1p. Saturday Review of Literature. 25 W. 45th St. New York 12; *Discussion.* Saturday Review of Literature. 28·19-20. S. 1; 20. S. 8; 18 S. 29, '45.

Saturday Review of Literature. 28.22-4. O. 13, '45. Sovereignty in an atomic age.

Saturday Review of Literature. 28·24. O. 13, '45. Letter from the Association of Oak Ridge Scientists at Clinton Laboratories.
Saturday Review of Literature. 28:14-15+. O 20, '45. Spelling out control.
Saturday Review of Literature. 28·14-15. D 22, '45. Cooperation or annihilation? R. R. Wilson
Saturday Review of Literature. 29:13-15. Ja. 12, '46 Fear in the atomic age. K A. Kraus and M. E. Kraus.
Saturday Review of Literature. 29:5-6. Mr 2, '46. Gentlemen, you are mad! Lewis Mumford
Saturday Review of Literature. 29.7-8+. Mr. 30, '46. No world, if necessary; review of One world or none, a report to the public on the full meaning of the atomic bomb; ed. by D. Masters and K Way. Elmer Davis.
Same. Congressional Record. 92:(daily)A2483-6 Ap. 26, '46
Saturday Review of Literature. 29·5-9+. Je. 15, '46 Beginning for sanity; review of Report on the international control of atomic energy. Norman Cousins and T. K. Finletter.
School and Society. 63·23-4. Ja. 12, '46. On the problem of splitting the atom for life, not death; report of special committee, Colgate University.
Science. 102:435-9 N. 2, '45 Atom and humanity. H. C Urey.
Same. International Conciliation. 416.790-800. D. '45.
Science. 102:441 N. 2, '45. Atomic energy act.
Science. 102:547-8 N. 30, '45 Pending legislation for federal aid to science; letter from Committee supporting the Bush report.
Science. 102:581-2. D. 7, '45. Promotion of science by the government; Western Reserve University Chapter of the Society of Sigma Xi and the Cleveland Physics Society recommendations.
Science. 103:4-6. Ja. 4, '46. National science foundation and the scientific worker R. W. Gerard.
Science. 103:110. Ja. 25, '46. Recommending an international control organization.
Science. 103:133-6. F 1, '46 Domestic control of atomic energy; with comparative summary of key Senate bills S. 1717, S. 1463 and S 1557, prepared by Senator McMahon and his staff. H. A. Meyerhoff.
Science. 103:158-60. F 8, '46 Another chain reaction Katherine Chamberlain.
Science. 103:232-3. F. 22, '46. Scientific faculty of Rutgers University petition President Truman and their Congressional representatives urging international control of atomic energy.
Science. 103:349-51. Mr. 22, '46. Can we curb the irresponsibles? L. K. Frank
Separate. 3p. The Author. Caroline Zackry Institute of Human Development. 17 E. 96th St. New York 28.
Science. 103:415-17. Ap. 5, '46. Science and our future. E. U. Condon.

Science News Letter 48:246 O. 20, '45. Prevent atom dangers, interview with Dr Niels Bohr. Gudrun Toksvig
Science News Letter. 48:250-2 O. 20, '45 Control of atomic power; text of a statement by scientists engaged in research at Oak Ridge, Tenn., laboratory.
Science News Letter. 48:259-60 O. 27, '45. Research to be supported.
Science News Letter. 48:260. O 27, '45. Atom research threatened; secrecy proposals threaten continued investigations.
Science News Letter. 48:274. N. 3, '45. Banish atomic dangers.
Science News Letter. 48:326. N. 24, '45. Banish atom production.
Science News Letter. 49:214. Ap. 6, '46. International control; report of State Department board of consultants.
Science News Letter. 49:223. Ap 6, '46. Civilian control demanded
Senior Scholastic. 47:3-5. N. 12, '45. Shall we share the atomic secret? forum discussion.
Senior Scholastic. 47:3-4. Ja. 7, '46. Government aid to research; Magnuson and Kilgore bills.
Senior Scholastic. 47:29. Ja. 21, '46. Don't share the bomb say high school student voters.
Spectator (London). 175:351. O. 19, '45 Atoms and politics.
Spectator (London). 175:451-2. N 16, '45. Bomb and the charter.
Steel 117:90-1. O. 15, '45 Scientists laud incentive system; Senate committees warned nation may lose leadership in scientific research.
Survey Graphic 34:407-8+, 429-31+; 76-8+, 124-5+, 158+, 204+. O.-N. '45: Mr -Je. '46. Bridges to the future J. T. Shotwell.
Time. 46.26. O 22, '45. Better than dynamite?
Time. 47·26-7. Ap. 8, '46. First hope, report of State Department's Committee on Atomic Energy.
Town Meeting (Bulletin of America's Town Meeting of the Air). 11, no 21.1-23. S. 20, '45. Who should control the atomic bomb? Raymond Swing, Hanson Baldwin, Owen Brewster and E. R. Murrow.
Town Meeting (Bulletin of America's Town Meeting of the Air). 11, no. 26:1-21. O. 25, '45. Should we share the secret of the atomic bomb with any other nation? J. H. Ball, Alexander Wiley, R. C. Gustavson and C G. Suits.
Town Meeting (Bulletin of America's Town Meeting of the Air). 11, no. 31:1-22. N. 29, '45 Does the atomic bomb make world government essential now? Raymond Swing, Reagan McCrary, Cord Meyer and G. F. Eliot.
Town Meeting (Bulletin of America's Town Meeting of the Air). 11, no. 48:1-24. Mr. 28, '46. Who should control the production and use of atomic energy? Brien McMahon, Edwin Johnson, H. G Douglas, and T. F. Farrell.
Town Meeting (Bulletin of America's Town Meeting of the Air). 12, no.10·3-24. Jl 4, '46. Should the Baruch proposals be adopted? Hanson Baldwin, Merle Miller, Chapman Revercomb and W. B. Ziff.

United States News. 19·24. Jl 27, '45. Sequel to research boom: contest for patent control.

United States News. 19.30-1. O. 19, '45. Government's role in science: a key to world leadership; issues behind bill to establish a national research foundation.

United States News. 19:92-8. O. 26, '45 Atomic bomb asset or threat? appraisal of weapon by nation's foremost scientists

United States News. 19·11-13. N 23, '45. Proffering the atom secret security for world as price; U S.-British-Canadian proposal for outlawing of mass destruction, with text of declaration.

United States News. 19 89-95. D 14, '45 Optimism on atom bomb; Dr. Bush's objections to fantastic thinking; testimony given to Senate Special Committee on Atomic Energy.

United States News. 20·69-70. Ja. 4, '46 Establishment by the United Nations of a commission for the control of atomic energy.

Same. Foreign Policy Reports. 21 296. Ja 15, '46, International Conciliation. 418:110-12 F. '46.

United States News. 20:74-5. F 22, '46. Senator McMahon's atomic crusade.

United States News. 20·34. Mr. 22, '46. Civilian or military authority over atomic policy: press views.

United States News. 20:80-1 Mr. 22, '46. Dr. Condon's war to free atom.

United States News. 20:54-5. Mr. 29, '46. Bernard Baruch's biggest assignment, demilitarizing the atom

United States News. 20:24-5. Ap. 5, '46 Uranium as world property from mine to atomic power.

United States News. 20·67-72. Ap. 5, '46 Atom-control program proposed by U S. board for discussion; official text.

United States News. 20·36-8 Ap 19; 36+. Ap. 26, 34-5. My 3, '46. Should the military or civilians have the deciding voice in the atomic energy policies of the United States?

*United States News. 20:57-9. My. 3, '46. Safeguarding atomic energy against misuse. Dean Acheson.

United States News 20:24. Je. 21, '46. Emerging policy on atom. continued federal control.

United States News. 21·16-17. Jl. 5, '46. What atom bomb means to U.S.: revision of plans for defense.

University of Chicago Round Table. 393 1-13 S 30, '45 Atom and world politics Norman Cousins, William Fox, William Hocking and Leo Szilard.

University of Chicago Round Table 399:1-13 N. 11, '45. Peace and the atomic bomb. Reuben Gustavson, Robert Hutchins and Robert Redfield.

University of Chicago Round Table 405.1-19. D. 23, '45. What about science legislation? Andrew Ivy, Edward Levi and Harold Urey.

University of Chicago Round Table. 407 1-27. Ja. 6, '46. Problem of the year: control of the atom. Thomas Finletter, Grayson Kirk, Edward Levi and Philip Morrison.

University of Chicago Round Table 416:1-24. Mr. 10, '46. Atomic energy and freedom. Harrison Brown, Austin Brues and Paul Henshaw

University of Chicago Round Table 424:1-38. My. 5, '46. Implications of atomic energy. R. G Gustavson, Joyce Stearns and Harold Urey.

University of Chicago Round Table. 431.1-28. Je. 23, '46 United Nations and the bomb. Thomas Finletter, Edward Shils and Harold Urey.

Vital Speeches of the day. 12:180-4. Ja. 1, '46. Peace is made by the living, not the dead W. G. Carleton.

Washington Post. Mr. 20-27, '46. Civilian vs military control of atomic age. Alfred Friendly

Reprint. 4p The Post. Washington, D.C.; Congressional Record. 92:(daily)A4568-81 Jl. 22, '46 (8 articles).

World Report. 1·22-3. Je. 6, '46. World and the atom bomb; question controlling future use depends on course Russia may take.

World Report 1:10-11. Je. 27, '46 Atom Authority plan faces twin barriers

*World Report. 1:26-7. Jl. 4, '46. Veto power—pro and con.

TESTS

Federation of American Scientists Scientists' comment on Bikini atoll tests. 5p. mim. The Federation. 1749 L St. Washington 6, D.C. My. 26, '46.

Same. Congressional Record. 92.(daily)8365-6. Jl. 3, '46

United States. House Committee on Naval Affairs. Authorizing use of naval vessels to determine effect of atomic weapons upon such vessels; report to accompany H. J. Res. 307. 4p. H. Rept. 1514. 79th Congress, 2d session. Supt of Docs Washington, D.C. F. 1 '46.

Aviation. 45.38-39+. Je. '46. Crossroads critique. Herb Powell.

Aviation. 45·38-41+ Ag '46 Evaluating operation crossroads. Scholer Bangs; Philip Swain.

Christian Century. 63 739. Je. 12, '46. Experimental bomb's effects covered continent

Christian Science Monitor Magazine Section. p. 2+. Je. 15, '46. Bikini: what will it prove? W. H. Stringer.

Collier's. 117.12-13+. Je. 8, '46. Atomic test case. W. H. P. Blandy.

Congressional Record 92·(daily)A1678-9. Mr. 22, '46. Atomic energy —will it bless or curse mankind? J. M. Robsion.

Congressional Record. 92:(daily)A1756-7. Mr. 26, '46. Thirty! W. L. Wartes.

Debaters' Digest. 20:27-31. Ap. '46. Should the postponed atomic bomb test be canceled? Yes!
Debaters' Digest. 20 33-41. My. '46. Should the postponed atomic bomb test be canceled? No!
Flying. 39:17+. Jl. '46 Is Bikini a fair test? ed. by D J. Ingells. H. A. Toulmin, Jr
Infantry Journal. 58:46-7. Ap. '46. Atomic bomb test
Iron Age. 157:105. My. 2, '46 Narrow margin wants Bikini bomb tests held, Gallup poll.
Iron Age. 157:42-7. Je. 13, '46. Fission at Bikini. T. W. Lippert.
Same. Spectator (Life ed) 153:6-11. Je '46
Life. 21 41-2+. Jl 1, '46. Bikini; forthcoming atomic bomb test. Eugene Kinkead.
Natural History. 55:290-2. Je. '46. Science at the crossroads. E D. Neff.
New Republic 114:892-5. Je. 24, '46. We take you now to Bikini Alan Harrington and Alexander Eliot.
New York Times. p. 6 Ag. 3, '46. Text of reports on Bikini bomb tests.
Popular Mechanics Magazine. 85:89-93+. Ap. '46. Operation crossroads. A. O. Cookman, Jr.
Popular Science Monthly. 148:77-81. Ap. '46. Navy at the crossroads. Leon Shloss.
Saturday Evening Post. 218.9-10+. Je. 22, '46 Phantom fortresses vs. the atom bomb. R M. Ramey.
Science. 103 674-5. My. 31, '46 Nuclear fission bomb as initiator of earthquakes. A. J. Shneiderov.
Science Digest. 19:8-11. My. '46 Will atom tests set sea afire? J. J. O'Neill.
Time. 48:20-2. Jl. 8, '46 Test for mankind.
United States News. 20:23-4. Mr. 8, '46 Dispute on atom-bomb test: what blasts at sea can show.
United States News. 21:25-6. Jl. 12, '46. What Bikini's atom test proved. navy's importance in defense.
United States News. 21 19. S. 20, '46. Why third atomic test is off.

Peacetime Benefits

*M. W. Kellogg Company. War's gift to peace. 10p. mim. J. M. Mathes. 122 E. 42d St. New York 17. S. 17, '45.
Same. 5,000 new products and procedures from atomic bomb research. Electrical Engineering. 64:375-7. O. '45; *Same.* Atomic by-products Mechanical Engineering. 67:748-51. N '45
Maisel, A. Q Atom can fight disease. 3p. National Committee on Atomic Information. 1749 L St. Washington 6, D.C.
Reprint from McCall's. Mr. '46.
Air Transport. 3:89+. S. '45. Control of atoms for fuel may require long research.

American Gas Association Monthly. 28 70. F. '46 Atomic research benefits; research and technological knowledge obtained as applied to industry. J. D. Tompkins.

American Gas Association Monthly 28·158+. Ap. '46 Future of nuclear power J. A. Wheeler.

American Petroleum Institute. Proceedings 25 (1)·71-83 '45 Petroleum vs. plutonium. Clark Goodman.
Same. Petroleum Refiner. 24.101-9. N. '45.

Atlantic Monthly. 177:68-73. Ja. '46 Medical uses of atomic energy. R D. Evans.

Automotive and Aviation Industries. 93:18-19+. D. 1, '45 Utilization of atomic energy. Clark Goodman.

Barron's 25:3. O. 8, '45. Atomic age will dawn gradually. J. V. Sherman.

Barron's 26:3+. Mr 11, '46. What atomic gold might do; synthesis at low cost would rock world's business, government. Franz Pick.

Barron's. 26:3+. Je. 24, '46. Atomic energy may become rival of coal. Warren Wells.

Business Week. p. 20. S. 15, '45. Atom power now? yes says Dr. Gustavson.

Business Week. p. 18-19. N. 10, '45. Atomic turbines; generation of electric power in atom-fueled plants feasible.

Business Week. p. 20-2. D. 15, '45. Atoms are news; imminent applications in industry and medicine.

Chemical and Engineering News. 23·1638+. S. 25, '45 General Electric officials answer questions on probable use of atomic power

*Chemical and Engineering News. 24 482-3+ F. 25, '46. Impact of nucleonics on medicine. R. S. Stone.

Chemical and Engineering News 24:897-9 Ap 10, '46 Biological applications of nucleonics. H J. Curtis.

Chemical and Engineering News. 24:1357-9 My 25, '46 Future of atomic energy; power phase. Enrico Fermi

Chemical and Engineering News. 24.1360-2 My 25, '46. Future of atomic energy; chemical phase. H. S. Taylor.

Coal Age. 51:166+. My '46. Atomic power development program announced by Manhattan District.

Collier's. 106:18-19. Jl. 6, '40. Fast new world; science unleashes a tremendous new source of energy; uranium 235. R M. Langer.

Commercial and Financial Chronicle. 162:2583. N. 29, '45. Business and atomic energy. R. W. Babson.

Commercial and Financial Chronicle. 162·3133+. D. 27, '45 Expert discusses international use of atomic power. J. R. Oppenheimer.

Commercial and Financial Chronicle. 163·2973+. My 30, '46. Revolutionary changes with atomic energy. Boris Pregel.

Diesel Power and Diesel Transportation. 23:1365. N. '45. Atomic power to drive gas turbines.

Edison Electric Institute Bulletin. 13:357-60+. D '45. Scientists explore possibilities of atomic power for electrical production; symposium before National Association of Manufacturers, New York, December 6, 1945.

Edison Electric Institute Bulletin 14:23. Ja. '46. Possibilities of atomic power. L. W. Chubb

Electrical Engineering 65:145-50 Ap. '46. Atomic power in a peacetime economy. C. G. Suits; P W. Swain; J. A Hutcheson.

Electrical World (News edition). 124:3-4. N. 3, '45 Public power bloc seeks future of atomic power.

Electrical World. 125:54-5. Mr. 2, '46 Atomic energy as a source of electricity supply; statement before Senate Committee on Atomic Energy by Association of Edison Illuminating Companies special committee

Electrical World (News edition). 125:3. Ap. 20, '46. Atomic power will fuel electric plant at Oak Ridge.

Industrial Marketing 30:39-40. S. '45 First commercial use of atomic energy may be in steam generation. H T. Heald.

Iron Age. 156:126+. S. 13, '45. ASME group sees atomic power for gas turbine drive.

Iron Age. 156:148+. S. 20, '45. Heating likely to be first application of nuclear energy; abstract. H. A. Winne and C. G. Suits.
Same. Blast Furnace and Steel Plant. 33:1263. O. '45.

Iron Age. 156:171-4. O 18, '45. Atomic power plant seen as possibility within ten years, abstract. A. H. Compton.

Lamp. 28:10-11. F. '46. Petroleum vs plutonium. Clark Goodman.

Mass Transportation. 41.162-5. Ag. '45. Free atomic power is here. Ross Schram.

Mechanical Engineering. 68:351-2 Ap. '46. Atomic-energy uses; symposium. J R. Dunning and others.

Nation. 161:568-9. D. 1, '45. Economics in the atomic age.

Nation 161:709-11. D. 22, '45. Atoms and industry. Stuart Chase; Boris Pregel; James Carey.

New Republic. 113:829-31. D 17, '45 Industrial uses of atomic power. Walter Isard and Vincent Whitney
Abridged. Management Review 35:16-17. Ja. '46.

New Republic 114:275-7. F. 25, '46. Peacetime uses of nuclear power. A. W. Weinberg.

New York Times. p. 21 S. 8, '46. Report on atom's use in industry, submitted to United Nations Atomic Energy Commission

New York Times Magazine. p 11+. Ag. 19, '45. Atom engine: how soon will it be? Waldemar Kaempffert.

New York Times Magazine p. 10+. D. 9, '45. When can the atom be put to work? H. M. Davis.

New York Times Magazine. p. 15+. S. 22, '46 Atom goes to work for medicine. H. M. Davis.

New Yorker. 21:15-16. Ag. 25, '45. 1945 Cassandra.

Newsweek 26:59-60. Ag. 20, '45. For the future
Newsweek. 26:76. D 17, '45. Peace work atom.
Oil and Gas Journal. 44:168. S 22, '45 Secondary results of atomic energy soon to be felt; abstract. R. E Fearon
Oil and Gas Journal 44:61. Mr. 23, '46. Atomic power deemed unsuitable for use in mobile units
Oil, Paint and Drug Reporter 149·3. Ap 22, '46. Atomic energy use for industrial power essayed by Monsanto Co.
Petroleum Refiner 24:129-32 O '45 Uses in petroleum industry for uranium atom. R E. Fearon
Petroleum Refiner. 24:101-9. N. '45 Petroleum vs. plutonium. Clark Goodman.
Same. American Petroleum Institute. Proceedings, November 12-15, 1945. p. 71-83 The Institute. 50 W 50th St. New York 20. '45
Popular Mechanics Magazine. 75·1-5. Ja. '41 Miracle of U-235; what life may be like in the uranium age. R. M. Langer.
Popular Mechanics Magazine. 77:62-3+. My. '42. Tracer bullets of science. E. U. Condon.
*Popular Mechanics Magazine. 84:1-6+. N. '45. Bringing the atom down to earth W. F. McDermott.
Same abridged with title Future of atomic power Science Digest. 19·67-72. Ja. '46.
Popular Science Monthly. 147·65-7+. O '45. What next with the atom? A M. Low.
Power. 90·174-6. Mr. '46 Future of nuclear power J A Wheeler.
Power Plant Engineering. 50.92 Ja. '46 Atomic energy was used to start radio station in 1940; article published in Power Plant Engineering in 1940.
Power Plant Engineering. 50·78-82. Ap. '46 Atomic energy for power generation. J. A Wheeler.
Same condensed. Power. 90.174-6 Mr. '46
Printers Ink 214·56 Ja. 18, '46. Atom bomb plant designers advertise man's hope
Public Utilities Fortnightly. 36:424-30. S. 27, '45. Power of the atom. R M Hyatt.
Public Utilities Fortnightly. 37 576-7. Ap. 25, '46. Possibilities of atomic energy studied by power industry.
Rotarian. 69:11+. Jl. '46 Atomic power for peace. S K. Allison.
Science and Society. 10·292-9. Summer '46. Development of atomic energy. J. K. Jacobs.
Science Digest. 18.85. N. '45 Atomic power units for our homes? H. T. Stetson
Science Digest. 18.71-2. D '45. Atomic power for gas turbines
Condensed from New York Times.
Science Digest 18. inside back cover. D. '45. Atom bomb's peace benefits.
Science Digest. 19.1-3 F. '46 Super atom energy from water? J. J. O'Neill.
Condensed from New York Herald Tribune. N. 25, '45.

Science News Letter 48:170-1 S. 15, '45. Precious waste products; by-products of the army's atomic plants.
Science News Letter 48.207. S 29, '45. Atom bomb benefits.
Science News Letter. 49.140. Mr. 2, '46. Peacetime atomic energy
Science News Letter. 49.248. Ap. 20, '46 Atomic power for future super-airliners.
Science News Letter. 49:265 Ap. 27, '46. Peacetime atomic plant is obvious development.
Science News Letter. 49:277 My. 4, '46 Atoms may revolutionize world social order.
Scientific American. 173·284-6. N. '45 How soon atomic energy?
Scientific American. 174:74-6+. F. '46. Industrial uses of atomic energy L. I Katzin.
Senior Scholastic 47.5. Ja. 7, '46. Harnessing atomic power for peace. Nancy Genet.
Survey Graphic. 34:357-8. S. '45 Atomic bombshell. S. C. Gilfillan.
Time. 47.74. Je. 17, '46. Piles for peace; General Electric to take over government-owned plant at Hanford, Wash.
Time. 47 74-5. Je. 17, '46. Isotopes for research.
United States News 21:52-3 Ag. 23, '46. Putting atomic power to use· how U S. controls are applied.
World Report. 1 45-7. S 10, '46. Future of atomic energy

ORGANIZATIONS

American Association for the United Nations, 45 E. 65th St, New York 21, N.Y.

American Broadcasting Co, 30 Rockefeller Plaza, New York 20, N Y.
Radio talks by Raymond Swing, 1945-1946.

Association of Los Alamos Scientists, Box 1663, Santa Fe, N.M

Association of Oak Ridge Scientists, Box 1251, Oak Ridge, Tenn

Association of Scientific Workers, 73 High Holborn, London WC1, England.

Atomic Scientists of Chicago, 1126 E 59th St., Chicago 37, Ill.
Publishes Bulletin of the Atomic Scientists twice a month. Vol 1, no 1, December 10, 1945

Carnegie Endowment for International Peace, 405 W. 17th St., New York 27, N.Y.

Emergency Committee of Atomic Scientists, 90 Nassau St., Princeton, N J.

Federal Council of the Churches of Christ in America, 297 4th Ave., New York 10, N.Y.

Federation of American Scientists, 1749 L St, Washington 6, D.C.

Fight for Total Peace, Inc, 16A E 62d St., New York 21, N.Y.

National Committee on Atomic Information, 1749 L St, Washington 6, D.C.
Publishes Atomic Information. Vol 1, no. 1, March 4, 1946.

National Policy Committee, 1202 National Press Bldg., Washington 4, D.C.

Social Science Foundation of the University of Denver, Denver, Colo.
Journeys behind the news, radio transcripts
Woodrow Wilson Foundation, 45 E. 65th St., New York 21, N.Y.
World Federalists. 29 E. 28th St., New York 16, N.Y.
World Peaceways, 103 Park Ave, New York 17, N.Y
World Wide Broadcasting Foundation, 298 Madison Ave., New York 22, N.Y.

Speech and Debating

Anthology of Public Speeches. Mabel Platz, comp. 895p. 1940. $3.75.
Selections from speeches representing all cultures from Pericles and Cicero to Chiang Kai-shek and Neville Chamberlain.

Competitive Debate: Rules and Strategy. By George McCoy Musgrave. 128p. 1945. $1.25.

Debate Coaching. By Carroll P. Lahman. (Handbook Series. Ser IV, Vol. 1) 2d rev. ed. 428p. 1936. $2.40.
A manual for teachers and coaches. Especially helpful to the inexperienced coach.

Discussion Methods: Explained and Illustrated. By J. V. Garland and C. F. Phillips (Reference Shelf. Vol. XII, No. 2) 2d ed. rev. 378p. 1940. $1.25.

High School Forensics: An Integrated Program. By Arnold E. Melzer. 153p. 1940. 90c.

How to Debate: A Textbook for Beginners. By H. B. Summers and F. L. Whan. 336p. 1940. $1.25.

Modern Group Discussion: Public and Private. By Lyman and Ellen Judson (Reference Shelf. Vol. XI, No. 6) 1937. 90c.

Oral Interpretation of Literature in American Colleges and Universities. By Mary Margaret Robb. 242p. 1941. $2.75.

Representative American Speeches. By A. Craig Baird, comp. Published annually in The Reference Shelf. Six volumes now available from 1937-1938 to 1944-1945 inclusive. 1938-39 o p. Price $1.25 a volume, except 1939-1940 which is $1.50.

Each volume contains representative speeches by eminent men and women on public occasions during the year. Each speech is prefaced by a short sketch of the speaker and the occasion.

Selected Readings in Rhetoric and Public Speaking. By Lester Thonssen, comp. 324p. 1942. $3.

University Debaters' Annuals

E. M. PHELPS, Ed. *Cloth. Price* $2.25

Series of yearbooks, each a collection of representative intercollegiate debates on important questions of the day. Constructive and rebuttal speeches for both sides. Each debate is accompanied by selected bibliography and briefs.

Vol. XXXII. 1945-1946.
Fraternities and sororities; The United States foreign economic policy; Ownership of patents on atomic energy; American college in the postwar world; Compulsory health insurance; British colonial policy in India; Compulsory arbitration of industrial disputes.

Vol. XXXI. 1944-1945.
The Partition of Germany; World Peace Settlement; Admission of All Races to State Universities; Cartels; Compulsory Military Training; Permanent Government Economic Controls; Settling Labor Disputes by Legislation.

Vol. XXX. 1943-1944. o.p.

Vol. XXIX. 1942-1943.
The Value of the College Woman to Society; A Planned Economy for the United States After the War; A Universal Draft of Man- and Woman-power; The War Marriage; A Federal World Government; A Permanent Federal Union; Blueprints for a Better World (Burton-Ball-Hatch-Hill Resolution); A Russian-United States Alliance.

Vol. XXVIII. 1941-1942.
Federal Incorporation of Labor Unions, A League of Nations; Military Training; Failure of Colleges to Meet Student Needs; A Federation of Democracies Based on the Churchill-Roosevelt Principles; A Federal Sales Tax; Compulsory Saving; Postwar Reconstruction; Western Hemisphere Solidarity; Freedom of Speech in Time of National Emergency.

Vol. XXVII. 1940-1941.
Industry Can Solve the Employment Problem; Conscription of Capital for Defense; Preservation of Democracy Through Decreased Government Control, Interstate Trade Barriers; Japanese Aggression; Union of United States and British Commonwealth of Nations; Regulation of the American Press; Compulsory Military Training; Strikes in Defense Industries; Western Hemisphere Defense.

Vol. XXVI. 1939-1940.
The Basis of a Lasting Peace; Shall the United States Enter the War?; Government Ownership and Operation of Railroads; Neutrality of the United States; Extension of Reciprocal Trade Agreements; The Third Term for President; Should the Roosevelt Administration Be Approved?; The Dies Committee; Civil Liberties; Labor; Foreign Affairs; Government and Business.